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National Dioxin Study Tier 4 Combustion Sources: Final Test Report Site 4, Black Liquor Boiler BLB-A

Radian Corp., Research Triangle Park, NC

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16. ABSTRACT

This report summarizes the results of a dioxin/furan emissions test of a black liquor recovery boiler equipped with a wet-bottom electrostatic precipitator for particulate matter emissions control. Black liquor recovery boilers are used at kraft pulp mills to produce process steam and to reclaim inorganic chemicals from spent wood pulping liquors. The test is the forth in a series of several dioxin/furan emissions tests being conducted under Tier 4 of the National Dioxin Study. The primary objective of Tier 4 is to determine if various combustion sources are sources of dioxin and/or furan emissions. If any of the combustion sources are found to emit dioxin or furan, the secondary objective of Tier 4 is to quantify these emissions.

Black liquor recovery boilers are one of 8 combustion source categories tested in the Tier 4 program. The test black liquor boiler, hereafter referred to as boiler BLB-A, was selected for this test after an initial information screening and a one-day pretest survey visit.

Data presented in the report include dioxin (tetra through octa homologue + 2378 TCDD) and furan (tetra through octa homologue + 2378 TCDF) results for stack samples. In addition, process data collected during sampling are also presented.

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Final Test Report — Site 4
Black Liquor Boiler BLB — A

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FOREWORD

This report is the result of a cooperative effort between the Office of Research and Development's Hazardous Waste Engineering Research Laboratory (HWERL) and the Office of Air Quality Planning and Standard's Monitoring and Data Analysis Division (MDAD). The overall management of Tier 4 of the National Dioxin Study was the responsibility of MDAD. In addition, MDAD provided technical guidance for the source test covered by this report. HWERL was directly responsible for the management and technical direction of the source test.

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1.0 INTRODUCTION

This report summarizes the results of a dioxin/furan[a] emissions test of a black liquor recovery boiler equipped with a wet-bottom electrostatic precipitator for particulate matter emissions control. Black liquor recovery boilers are used at Kraft pulp mills to produce process steam and to reclaim inorganic chemicals from spent wood pulping liquors. The test is the fourth in a series of several dioxin/furan emissions tests being conducted under Tier 4 of the National Dioxin Study. The primary objective of Tier 4 is to determine if various combustion sources are sources of dioxin and/or furan emissions. If any of the combustion sources are found to emit dioxin or furan, the secondary objective of Tier 4 is to quantify these emissions.

Black liquor recovery boilers are one of 16 combustion source categories being considered in the Tier 4 program. The tested black liquor boiler, hereafter referred to as boiler BLB-A, was selected for this test after an initial information screening and a one-day pretest survey visit. Boiler BLB-A is considered representative of new black liquor recovery boilers built in the last 5 to 10 years. The amount of chlorides present in the black liquor circuit at this site is typical of that found at other Kraft pulp mills.

This test report is organized as follows. A summary of test results and conclusions is provided in Section 2.0, followed by a detailed process description in Section 3.0. The source sampling and analysis plan is outlined in Section 4.0, and the dioxin test data are presented in Section 5.0. Sections 6.0 through 9.0 present various testing details. These include descriptions of the sampling locations and procedures (Section 6.0), descriptions of the analytical procedures (Section 7.0), and a summary of the quality assurance/quality control results (Section 8.0). The appendices contain data generated during the field sampling and analytical activities.

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[a] The term "dioxin/furan" and the acronyms PCDD and PCDF as used in this report refer to the polychlorinated dibenzo-p-dioxin and dibenzofuran homologues with four or more chlorine atoms.

2.0 SUMMARY

2.1 SOURCE SAMPLING AND ANALYSIS OVERVIEW

The host plant (Site 04) is a Kraft pulp mill that produces pulp and paper products. Black liquor recovery boiler BLB-A combusts concentrated spent liquor from the pulping process and recovers the inorganic chemicals used to produce pulp from wood chips. Particulate matter emissions from black liquor boiler BLB-A are controlled by a wet bottom electrostatic precipitator. A simplified process flow diagram of the system is shown in Figure 2-1.

The gaseous, liquid, and solid sampling performed during the test program is summarized in Table 2-1. Sampling for dioxin and furan was performed simultaneously at the electrostatic precipitator outlet exhaust stack and the electrostatic precipitator inlet location (i.e., black liquor boiler outlet) in each of a series of three test runs conducted on December 11 through 14, 1984. The dioxin/furan sampling was based on the October 1984 draft of the Modified Method 5 (MM5) procedure developed by the American Society of Mechanical Engineers (ASME) for measuring emissions of chlorinated organic compounds from municipal waste incinerators. Modifications to the ASME protocol are discussed in Section 6. MM5 train components and train rinses were analyzed for dioxins and furans by EMSL-TRP and ECL-BSL, two of three EPA laboratories collectively known as Troika. The dioxin/furan analysis quantified the 2378-TCDD* isomer and the tetra- through octa- dioxin/furan homologues present in the samples.

Dioxin/furan and dioxin/furan precursor analyses were performed on samples of the concentrated black liquor fed to the boiler. The black liquor dioxin/furan analyses were performed by EPA ECL-BSL and EMSL-RTP laboratories, and the dioxin precursor analyses were performed by Radian. The specific dioxin precursors analyzed for were chlorophenols, chlorobenzenes, polychlorinated biphenyls, and total chlorine. Samples of black liquor circuit intermediates (caustic, white liquor, and weak black liquor) and ClO_2

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*The terms TCDD and TCDF as used in this report refer to tetrachloro dibenzo-p-dioxin and tetrachlorodibenzo furan.

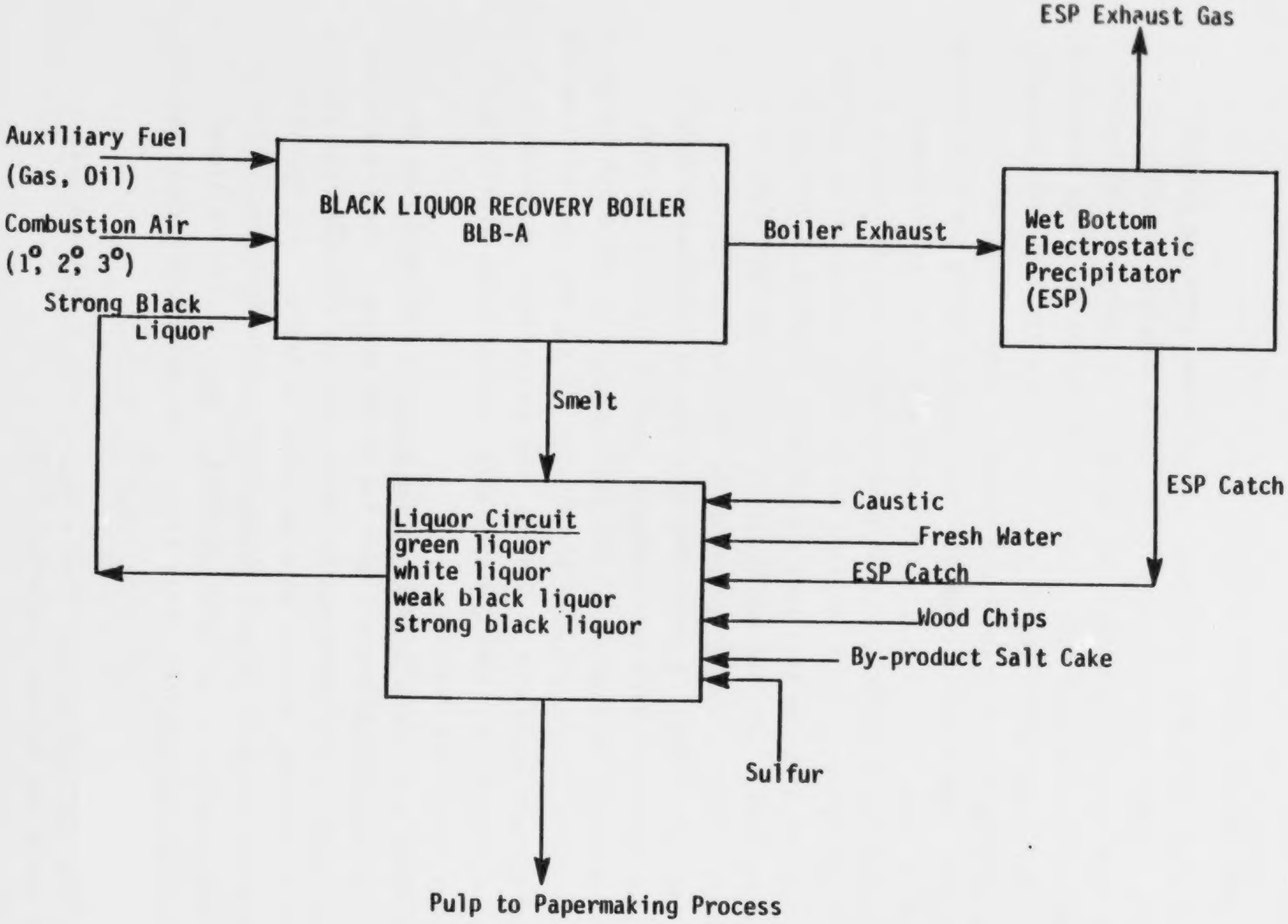

ESP Exhaust Gas
Auxiliary Fuel
(Gas, Oil)
Combustion Air
(1°, 2°, 3°)
Strong Black Liquor
BLACK LIQUOR RECOVERY BOILER
BLB-A
Boiler Exhaust
Wet Bottom Electrostatic Precipitator (ESP)
Smelt
ESP Catch
Liquor Circuit
green liquor
white liquor
weak black liquor
strong black liquor
Caustic
Fresh Water
ESP Catch
Wood Chips
By-product Salt Cake
Sulfur
Pulp to Papermaking Process

Figure 2-1. Simplified Process Flow Diagram of Black Liquor Recovery Boiler System BLB-A

TABLE 2-1. SOURCE SAMPLING AND ANALYSIS OVERVIEW

Item	Item Description
1. Number of test runs	- Three identical test runs (Runs 1, 2, 3).
2. Gaseous Sampling	- MM5 sampling at black liquor boiler outlet and ESP outlet exhaust stack (Runs 1, 2, 3). Dioxin/furan analysis.
	- EPA Refernce Methods 2 and 4 at black liquor boiler outlet and ESP outlet exhaust stack (Runs 1, 2, 3). Gas velocity and moisture.
	- Integrated bag sampling at black liquor boiler outlet and ESP outlet exhaust stack (Runs 1, 2, 3). CO_2, O_2, N_2 analysis for molecular weight determination.
	- HCl sampling at ESP Outlet exhaust stack (Runs 1, 2, 3). HCl analysis.
	- Continuous monitoring of CO, CO_2, O_2, SO_2, and NO_x, total hydrocarbons at black liquor boiler outlet (Runs 1, 2, 3).
3. Liquid Sampling	- Strong black liquor sampling[a] (Runs 1, 2, 3,). Dioxin/furan analysis, dioxin/furan precursor analysis, and total chlorine analysis.
	- Caustic sampling (Runs 1, 2, 3). Total chlorine analysis.
	- White liquor sampling (Runs 1, 2, 3). Total chlorine analysis.
	- Weak black liquor sampling (Runs 1, 2, 3). Total chlorine analysis.
	- ClO_2 generation system by-product salt cake sampling (Runs 1, 2, 3). Total chlorine analysis.
4. Solids Sampling	- Soil sampling[a] (one composite sample from 10 locations). Potential dioxin/furan analysis.

[a] Sample(s) to be analyzed pending evaluation of the dioxin/furan emissions data from the MM5 sampling train.

generation system by-product salt cake that is fed to the black liquor circuit were taken and analyzed by Radian for total chlorine. The total chlorine analyses of these streams were used to quantify the major chlorine inputs to the black liquor circuit. A single composite soil sample was also taken, but analysis of this sample was deferred pending evaluation of the dioxin/furan emissions data.

Continuous emissions monitoring (CEM) was performed at the electrostatic precipitator inlet location for CO, CO_2, NO_x, SO_2, total hydrocarbons (THC), and O_2. Total reduced sulfur (TRS) monitoring data taken regularly by the plant at the ESP outlet exhaust stack were also obtained. Plant personnel calibrated the TRS monitoring instrument daily during the test program. The continuous monitoring data were used in conjunction with process data to document the stability of combustion conditions during the test.

2.2 SUMMARY OF RESULTS

The data obtained at Site BLB-A during the Tier 4 test program are summarized in Figure 2-2. Only the hepta- and octa-CDD species were consistently detected in the stack gas at the outlet from the ESP. For the furan species, the tetra-, hexa-, hepta- and octa-CDF homologues were consistently detected in the ESP outlet gas stream. As shown in Table 2-2, average as-measured stack gas concentrations of the total PCDD and total PCDF at the ESP outlet were 0.67 ng/dscm and 0.51 ng/dscm, respectively. The average hourly emission rates were 150 ug/hr for total PCDD and 114 ug/hr for total PCDF. Octa-CDD was the most prevalent of the tetra- through octa-chlorinated dioxin homologues, while the furans were fairly evenly distributed among the tetra- through octa-chlorinated furan homologues. The ESP appeared to have positive control for reducing dioxin/furan emissions although analytical uncertainties inherent in GC/MS analysis limited the ability to quantify the control efficiency accurately.

Analysis of the flue gas samples taken at the ESP inlet did not detect any 2378 TCDD or 2378 TCDF. Detectable quantities of PCDD and PCDF homologues were found in the inlet flue gas to the ESP. Average as-measured stack gas concentrations of total PCDD and total PCDF at the ESP inlet were 1.59 ng/dscm

Black Liquor Boiler Operating Data Ⓐ

Feedrate	395 gpm
Operating hours	8,760 hrs/yr

ESP Operating Data Ⓑ

Inlet temperature	178°C
Inlet gas flowrate:	
East duct	1,800 dscmm
West duct	1,800 dscmm
Total	3,600 dscmm

Black Liquor Feed Precursor Data Ⓖ

Chlorobenzenes	ND
PCB's	ND
Chlorophenols	trace
Total chlorides	896 ppm

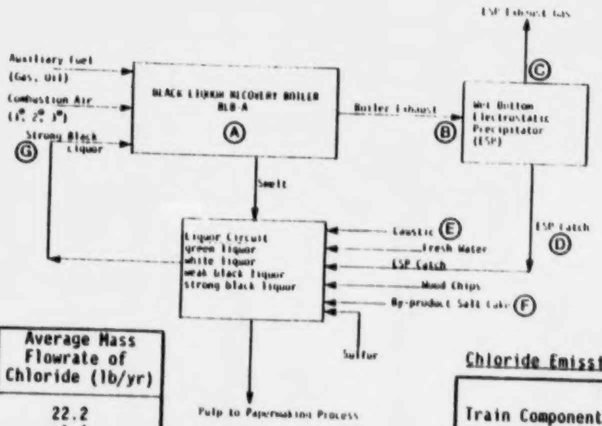
Liquor Circuit Inputs Ⓔ Ⓕ

Stream	Flowrate	Total chlorides Concentration (ppm, wet basis)	Average Mass Flowrate of Chloride (lb/yr)
Caustic	25-30 gpm	1300	22.2
By-product salt cake	24 TPD	700	1.4

Dioxin/Furan Emissions Data

Species	Concentration (ng/dscm @ 3% O_2)	Emission Rate (ug/hr)	Emissions Factor (pg/kg feed, dry)
Ⓑ INLET:			
2378 TCDD	ND	--	--
Total PCDD	1.79	339	60
Total PCDF	1.47	283	50
Ⓒ OUTLET:			
2378 TCDD	ND	--	--
Total PCDF	0.75	150	3
Total PCDF	0.57	114	2

NR - not reported; ND - not detected.



Auxiliary fuel (Gas, Oil)
Combustion Air (1°, 2°, 3°)
Strong Black Liquor
Ⓖ
BLACK LIQUOR RECOVERY BOILER BLB-A
Ⓐ
Boiler Exhaust
Ⓑ
Wet Bottom Electrostatic Precipitator (ESP)
Ⓒ
ESP Exhaust Gas
ESP Catch
Ⓓ
Smelt
Liquor Circuit
green liquor
white liquor
weak black liquor
strong black liquor
Caustic Ⓔ
Fresh Water
ESP Catch
Wood Chips
By-product Salt Cake Ⓕ
Sulfur
Pulp to Papermaking Process

Continuous Monitoring Data Ⓒ

O_2	6.0 %vol, dry
CO_2	15.6 %vol @ 3% O_2, dry
CO	136.4 ppmv @ 3% O_2, dry
THC	3.5 ppmv @ 3% O_2, wet
SO_2	94.4 ppmv @ 3% O_2, dry
NO_x	83.2 ppmv @ 3% O_2, dry

Flue Gas Parameter Data

Ⓑ INLET:	Flowrate	3,600 dscmm
	Temperature	178°C
	Moisture	28 vol%
Ⓒ OUTLET:	Flowrate	3,700 dscmm
	Temperature	173°C
	Moisture	25 vol%

Chloride Emissions Data Ⓒ

Train Component	Concentration (mg/dscm @ 3%O_2)	Emission Rate (kg/hr)	Emission Factor (mg/kg feed, dry)
Front half	1.5	0.3	0.9
Back half	108.9	21.5	614.8
Train total	110.4	21.8	615.7

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Figure 2-2. Data summary for Site BLB-A.

TABLE 2-2. SUMMARY OF MEAN DIOXIN AND FURAN EMISSIONS DATA FOR SITE BLB-A

Parameter	2378 TCDD[a]	Total PCDD	Total PCDF
INLET:			
Emissions Concentration (ng/dscm)			
As-measured	ND	1.59	1.31
Corrected to 3% O_2	--	1.79	1.47
Emissions Rate (ug/hr)	--	339	283
OUTLET:			
Emissions Concentration (ng/dscm)			
As-measured	ND	0.67	0.51
Corrected to 3% O_2	--	0.75	0.57
Emissions Rate (ug/hr)	--	150	114

[a] Values in parenthesis are detection limits expressed in the corresponding units.

ND - Not detected.

and 1.31 ng/dscm respectively. The hourly emission rates were 339 ug/hr for total PCDD and 283 ug/hr for total PCDF. The octa-chlorinated dioxin homologue was the predominant dioxin species while the furan species were distributed fairly evenly among the tetra- through hepta-CDF homologues.

Chloride emissions at the ESP outlet were measured at 98.1 mg/dscm which corresponds to 110.4 ng/dscm @ 3% O_2. The average chlorides emission factor was calculated to be 615.7 mg chloride emitted per kilogram of black liquor fired on a dry basis.

The black liquor feed rate to Boiler BLB-A was 395 gpm during the test period. Precursor analysis of the black liquor did not detect chlorobenzenes or polychlorinated biphenyls. A trace amount of chlorophenols were detected, and the black liquor contained 896 ppm of total chlorides.

The ESP treated an average of 3,600 dscmm at a temperature of 178°C. At the ESP outlet, the measured flowrate was 3,700 dscmm at a temperature of 173°C. Average flue gas concentrations measured at the ESP outlet by the Radian continuous emissions monitoring system were: O_2, 6.0 vol%; CO_2, 15.6 vol% @ 3% O_2 (dry); CO, 136.4 ppmv @ 3% O_2; THC, 3.5 ppmv @ 3% O_2, wet; SO_2, 94.4 ppmv @ 3% O_2, dry; and NO_x, 83.2 ppmv @ 3% O_2, dry.

3.0 PROCESS DESCRIPTION

This section describes the host site and the black liquor recovery boiler/electrostatic precipitator system tested. Data summarizing the operation of the boiler and the precipitator during the test periods are presented in Section 5.0.

3.1 FACILITY DESCRIPTION

The host plant (Site 04) is a typical Kraft pulp and paper mill with a rated capacity of 855 Mg/day (940 TPD) of air-dried pulp. The plant maintains three black liquor recovery boilers with rated capacities of 365 Mg/day (400 TPD), 590 Mg/day (650 TPD), and 815 Mg/day (900 TPD) of air-dried, unbleached pulp. Two of the three black liquor boilers were operating during the dioxin/furan tests, while the third was being modified for future use. These boilers are typically base-loaded. Two combination boilers firing bark, wood refuse, and non-condensible gases from the black liquor evaporators are swing-loaded to cover variations in process steam demand.

Pine logs and pine wood chips are transported to Site BLB-A by truck. To the best knowledge of plant personnel, none of the wood processed in the pulping circuit has been stored in salt water or treated with pentachlorophenol (PCP). Approximately 80 digester batches per day are processed in the 10 digesters at the pulping plant. Each batch consists of 55 Mg (60 tons) of wood chips, 42 cubic meters (1500 ft^3) of white liquor, and a small amount of weak black liquor.

The contents of the finished digester batches are sent to a "blow tank" for intermittent storage and then to a countercurrent "brown stock washer" system. Pulp is separated from the rest of the finished digestor batch in the brown stock washers. Dirty water from the brown stock washers (i.e., weak black liquor) is sent to an evaporator system for solids concentration prior to being fired in the black liquor boiler. Typical process flow rates of various streams in the pulp mill circuit are shown in Table 3-1.

TABLE 3-1. TYPICAL PROCESS FLOW RATES OF VARIOUS PULP MILL MATERIALS AT SITE BLB-A

Material	Process Flow Rate	Other Information
-By-product salt cake	24 tons/day	Predominantly sodium sulfate
-White liquor	620 gpm	Sodium sulfide/ sodium hydroxide
-Weak black liquor	1800-2000 gpm	18 wt % solids density 8.7 lb/gal
-Strong black liquor	395 gpm[a]	65 wt % solids density 11.8 lb/gal
-Caustic	15-30 gpm[b]	20% Sodium Hydroxide

[a] No. 3 recovery boiler (BLB-A), 260 gpm; No. 1 recovery boiler, 135 gpm.

[b] Caustic flow rate during tests was 25-30 gpm.

Cleaned pulp from the brown stock washer is bleached, pressed, and rolled into a variety of paper products. Bleaching is performed using chlorine dioxide (ClO_2), which is produced on-site using the the R3 process. Approximately 22 Mg/day (24 tons/day) of by-product salt cake (predominantly sodium sulfate, Na_2SO_4) from this process is fed to the black liquor circuit as a make-up material for sodium and sulfur losses. According to plant personnel, the atomic chlorine content of the by-product salt cake ranges from approximately 0.2 to 1.5 weight percent. Most of this chlorine is present in the form of chloride ion.

3.2 BLACK LIQUOR RECOVERY BOILER DESCRIPTION

Black liquor recovery boiler BLB-A is a low odor Babcock and Wilcox recovery boiler with a rated capacity of 815 Mg/day (900-TPD) unbleached pulp. A schematic diagram of the pulping process is shown in Figure 3-1. The boiler is typically baseloaded and operates at a steady black liquor firing rate. Particulate matter emissions from the boiler are controlled by a wet bottom electrostatic precipitator.

The solids content of the concentrated black liquor fired in Boiler BLB-A is approximately 65 percent by weight. Concentration of the weak black liquor produced by the brown stock washers is accomplished using a three-stage multiple effect evaporator system and a "concentrator," which is essentially a large single stage evaporator. Noncondensible gases collected by the evaporator system are fired in one of the two combination power boilers at the plant. Strong black liquor from the concentrator flows through the bottom of the electrostatic precipitator that controls particulate matter emissions from boiler BLB-A. The precipitator catch is mixed with the strong black liquor before the liquor is fired in the boiler.

According to plant personnel, the chloride content of the concentrated black liquor fed to boiler BLB-A is typically 0.5 weight percent chlorine (wt % Cl), with a range of approximately 0.1 to 0.7 wt % Cl. Chlorine enters the black liquor circuit as inorganic chloride ions primarily through the ClO_2 generation system byproduct salt cake that is added to the weak black liquor

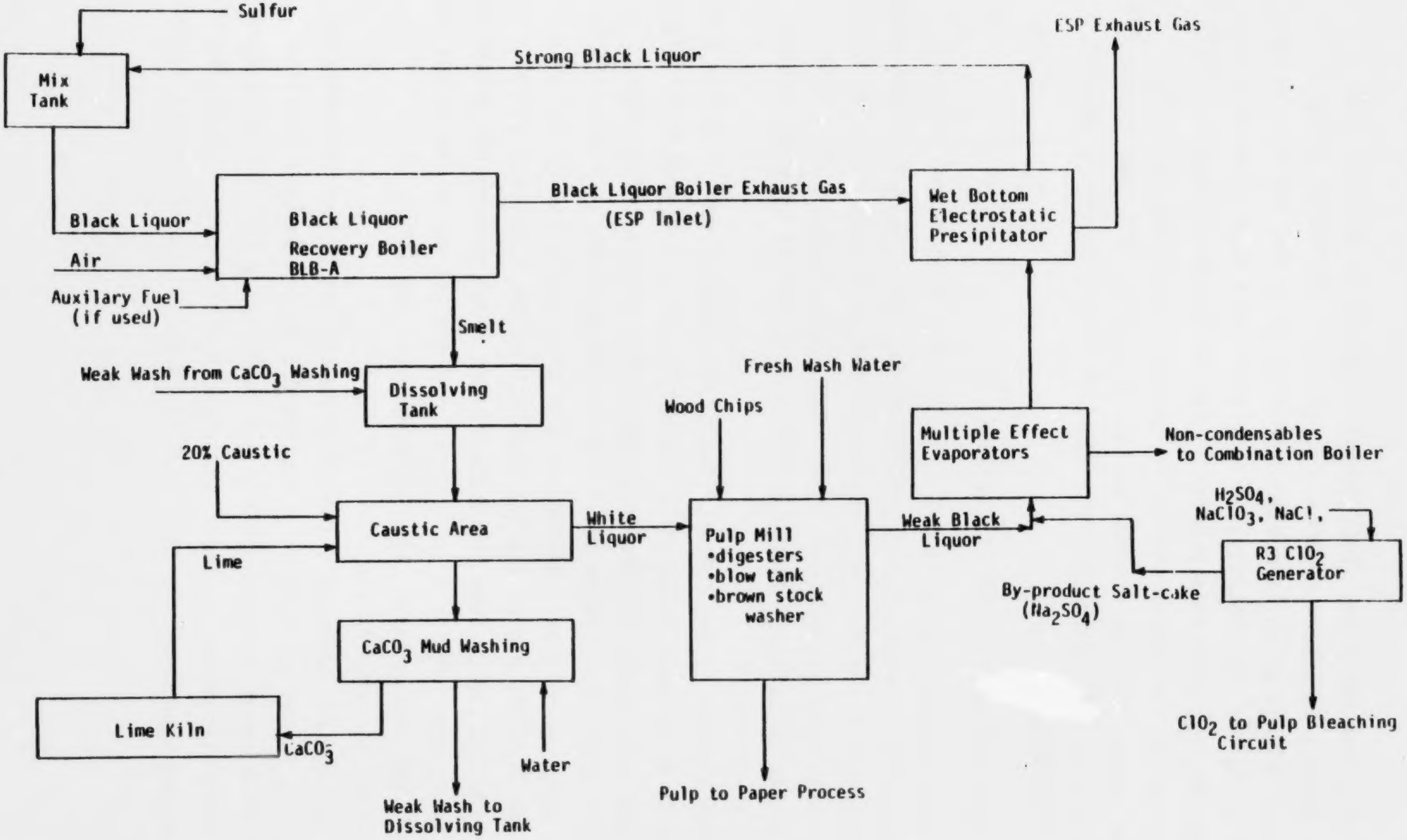
Sulfur
Mix Tank
Strong Black Liquor
ESP Exhaust Gas
Black Liquor
Air
Auxilary Fuel (if used)
Black Liquor Recovery Boiler BLB-A
Black Liquor Boiler Exhaust Gas
(ESP Inlet)
Wet Bottom Electrostatic Presipitator
Smelt
Weak Wash from CaCO3 Washing
Dissolving Tank
20% Caustic
Caustic Area
Lime
White Liquor
Wood Chips
Fresh Wash Water
Pulp Mill
•digesters
•blow tank
•brown stock washer
Weak Black Liquor
Multiple Effect Evaporators
Non-condensables to Combination Boiler
H2SO4, NaClO3, NaCl,
R3 ClO2 Generator
By-product Salt-cake (Na2SO4)
ClO2 to Pulp Bleaching Circuit
CaCO3 Mud Washing
Lime Kiln
CaCO3
Water
Weak Wash to Dissolving Tank
Pulp to Paper Process

Figure 3-1. Process Flow Diagram for Site BLB-A

prior to the evaporators. The by-product salt cake contributes makeup sodium and sulfur to the black liquor circuit. The chlorine content of the by-product salt cake ranges from about 0.2 to 1.5 wt % Cl. Other potential sources of chlorine in the black liquor circuit are sodium hydroxide used in the conversion of green liquor to white liquor, wood chips fed to the pulping process, and fresh water used for $CaCO_3$ mud washing and pulp washing. Data on the relative amounts of chlorine added to the black liquor circuit through each of these sources have been developed from total chlorine analyses performed on process samples taken during the dioxin/furan tests.

Concentrated black liquor is sprayed into the combustion zone of boiler BLB-A at a temperature of approximately $105^{o}C(250^{o}F)$ using four oscillating "guns". Primary, secondary, and tertiary combustion air is supplied to the boiler by forced draft fans. The primary:secondary:tertiary air ratio is approximately 1.4:1.8:1.0. The combustion air supply is computer controlled using flue gas oxygen monitoring and black liquor feed rate monitoring. Oxygen is continuously monitored at the economizer section of the boiler and at the electrostatic precipitator outlet stack, while carbon monoxide, opacity, and total reduced sulfur(TRS) are continuously monitored only at the electrostatic precipitator outlet stack. The target flue gas oxygen at the economizer section is 3.0 to 3.5 percent O_2. Opacity at the outlet stack is typically 15 percent. The Federal New Source Performance Standards (NSPS) TRS emissions limit for black liquor recovery boiler stacks is 5 ppm corrected to 8 percent oxygen. Plant personnel reported that boiler BLB-A is in compliance with the NSPS.

3.3 ELECTROSTATIC PRECIPITATOR DESCRIPTION

Exhaust gases from black liquor recovery boiler BLB-A pass through a two-chamber Wheelabrator-Frye wet bottom electrostatic precipitator (ESP) for particulate removal. Each chamber of the precipitator handles approximately half of the total boiler exhaust gas flowrate. The ESP was designed for a total gas flowrate of 110,000 acmm (387,000 acfm) at an operating temperature of $175^{o}C$ ($350^{o}F$). Total plate collection area is 17,150 m^2 (184,570 ft^2), corresponding to a design specific collection area of approximately 0.16

m^2/acmm (0.5 ft^2/acfm). An energy management system trims the power supply to the ESP to maintain a stack opacity of approximately 15 percent. The design particulate matter removal efficiency of the ESP is 99.6 percent when operated at full electrical power. Under typical power supply conditions, the particulate matter removal efficiency of the ESP is estimated by plant personnel to be 98.6 to 99.0 percent. The most recent particulate matter emissions data generated by the host plant showed a particulate grain loading of 0.005 gr/dscf in the precipitator exhaust gas.

4.0 TEST DESCRIPTION

This section describes the field sampling, process monitoring, and analytical activities that were performed for test Site 04. The purpose of this section is to provide sufficient descriptive information about the test so that the test data presented in Section 5.0 can be easily understood. Specific testing details (specific sampling locations and procedures) are presented in Section 6.0.

This section is divided into three parts. Section 4.1 summarizes field sampling activities, Section 4.2 summarizes process monitoring activities, and Section 4.3 summarizes analytical activities performed during the test program.

4.1 FIELD SAMPLING

Table 4-1 shows the source sampling and analysis matrix for test Site BLB-A. Three dioxin/furan emissions tests (Runs 01, 02, 03) were performed. Samples were taken simultaneously at the electrostatic precipitator (ESP) inlet location and the ESP outlet exhaust stack. These locations are shown as Points B and C on Figure 4-1. Dioxin/furan sampling followed the Modified Method 5 (MM5) sampling protocol developed by the American Society of Mechanical Engineers (ASME) for measuring emissions of chlorinated organic compounds. Testing was performed at the ESP outlet exhaust stack for a period corresponding to 240 minutes of on-line sampling. Testing was performed during the same time period at the ESP inlet location, but due to a number of filter changes and sample port changes the on-line sampling period for the inlet train was typically about 140 minutes.

Concentrations of HCl in the flue gas were determined for each test day at the ESP outlet exhaust stack using another modification of EPA Method 5. The sampling train was identical to that of Method 5 except that water in the impingers was replaced with 0.1 M NaOH or 0.1 M KOH. Sodium hydroxide (NaOH) was used in the impinger during Run 01 according to typical HCl sampling procedures. The impinger solution was changed to potassium hydroxide for

TABLE 4-1. SOURCE SAMPLING AND ANALYSIS MATRIX FOR SITE 04

Sample Location	Sample Type or Parameter	Sampling Method	Analytical Method	Number of Samples or Frequency
1. Electrostatic precipitator outlet exhaust stack (Point C, Figure 4-1)	Dioxin, furan	Modified EPA Method 5 (MM5)	Gas chromatograph/mass spectrometer	Three test runs; one per test day
	Volumetric flow	EPA Method 2	S-type pitot	Once per MM5 test run
	Molecular weight	EPA Method 3	Gas chromatography/thermal conductivity detector	Two integrated bag samples per MM5 test run
	Moisture	EPA Method 4	Gravimetric balance	Once per MM5 test run
	HCl	Modified EPA Method 5 (MM5/HCl)	Ion chromatography	Once per MM5 test run
2. Electrostatic precipitator inlet/black liquor boiler outlet (Point B, Figure 6-1)	Dioxin, furan	Modified EPA Method 5	Gas chromatograph/mass spectrometer	Three test runs; one per test day
	Volumetric flow	EPA Method 2	S-type pitot	One per MM5 test run
	Molecular weight	EPA Method 3	Gas chromatography/thermal conductivity detector	Two integrated bag samples per MM5 test run
	Moisture	EPA Method 4	Gravimetric balance	Once per MM5 test run
	CO/CO_2	In-stack filter probe and heat-traced Teflon sample line	Nondispersive infrared analyzer	Continuously during MM5 test runs
	O_2	Same as CO/CO_2	Paramagnetic analyzer	Continuously during MM5 test runs
	NO_x	Same as CO/CO_2	Chemiluminescent analyzer	Continuously during MM5 test runs
	SO_2	Same as CO/CO_2	Pulsed fluorescence analyzer	Continuously during MM5 test runs
	Total hydrocarbons (THC)	Same as CO/CO_2	Flame ionization analyzer	Continuously during MM5 test runs
3. Strong black liquor mix tank	Strong black liquor for dioxin/furan, dioxin/furan precursors, and total chloride analyses	Grab samples	Gas chromatography/mass spectrometer, ion chromatography	Three identical samples of hourly sample composites for each MM5 test run
4. Caustic line from storage area to liquor circuit	20% caustic for total chloride analysis	Tap valve samples	Ion chromatography	One composite of two samples taken during each test run
5. White liquor storage tank	White liquor for total chloride analysis	Tap valve samples	Ion chromatography	One composite of two samples taken during each test run

TABLE 4-1. SOURCE SAMPLING AND ANALYSIS MATRIX FOR SITE 04 (Con't.)

Sample Location	Sample Type or Parameter	Sampling Method	Analytical Method	Number of Samples or Frequency
6. Weak black liquor line leading to concentrators	Weak black liquor for total chloride analysis	Tap valve samples	Ion chromatography	One composite of two samples taken during each test run
7. Byproduct salt cake rotary filter in ClO_2 plant	Byproduct salt cake for total chloride analysis	Grab samples	Ion chromatography	One composite of two samples taken during each test run
8. Plant property	Soils for dioxin, furan	Grab samples	Gas chromatograph/mass spectrometer	One composite of ten samples taken at various locations

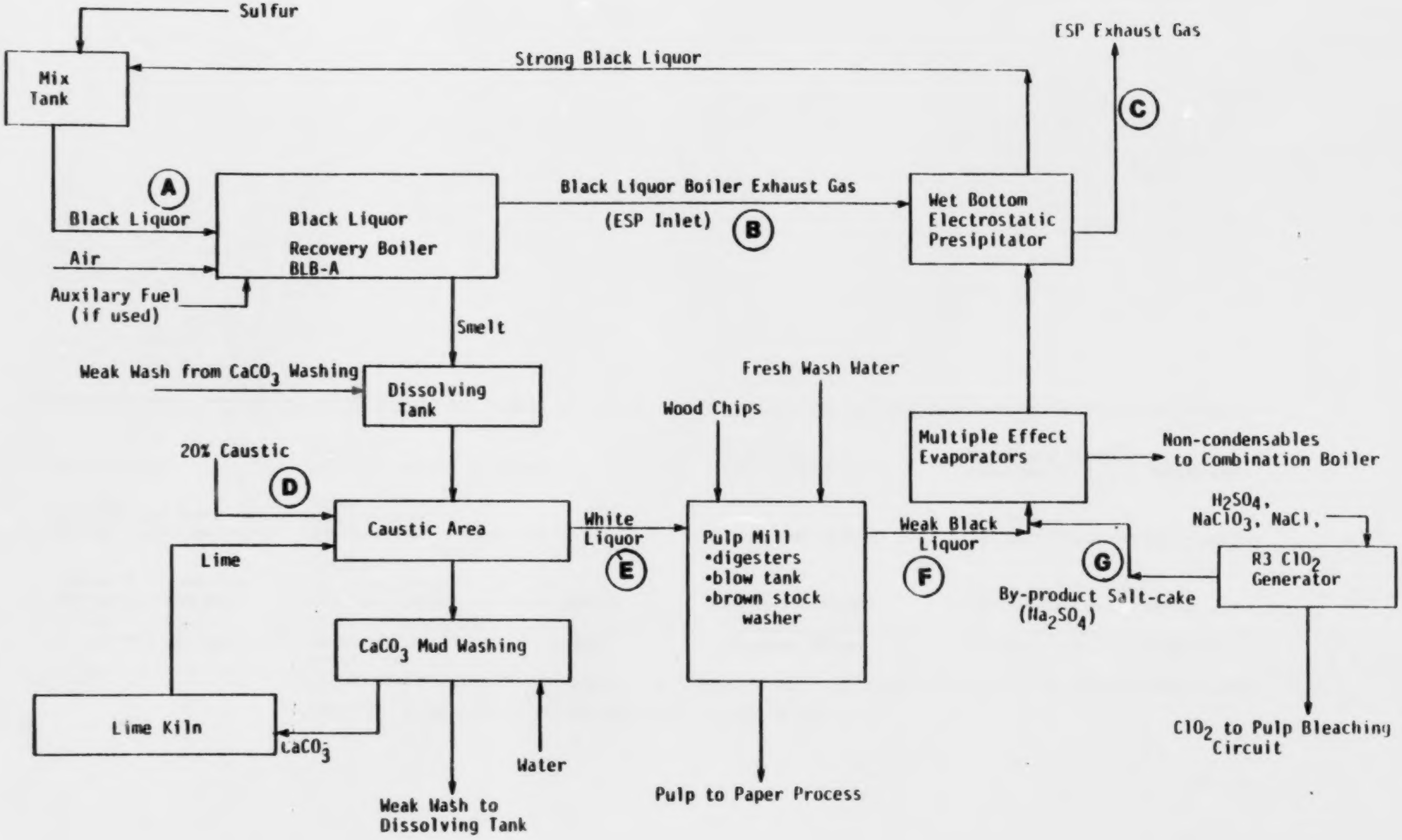
Sulfur
Mix Tank
Strong Black Liquor
ESP Exhaust Gas
C
A
Black Liquor
Air
Auxilary Fuel (if used)
Black Liquor Recovery Boiler BLB-A
Black Liquor Boiler Exhaust Gas
(ESP Inlet)
B
Wet Bottom Electrostatic Presipitator
Smelt
Weak Wash from CaCO3 Washing
Dissolving Tank
Fresh Wash Water
Wood Chips
Multiple Effect Evaporators
Non-condensables to Combination Boiler
20% Caustic
D
Caustic Area
Lime
White Liquor
E
Pulp Mill
•digesters
•blow tank
•brown stock washer
Weak Black Liquor
F
G
H2SO4, NaClO3, NaCl,
R3 ClO2 Generator
By-product Salt-cake (Na2SO4)
CaCO3 Mud Washing
Lime Kiln
CaCO3
Water
Weak Wash to Dissolving Tank
Pulp to Paper Process
ClO2 to Pulp Bleaching Circuit

Figure 4-1. Sample Point Diagram for Black Liquor Recovery Boiler System BLB-A

subsequent runs at the suggestion of the National Council for Air and Stream Improvement (NCASI). The substitution of KOH in the impinger was performed in an effort to eliminate sodium chloride (NaCl) interferences in the HCl measurement.

Continuous emissions monitoring (CEM) of O_2, CO, CO_2, SO_2, NO_x, and total hydrocarbons (THC) was performed during the three MM5 test runs. These data were obtained to assess variations in combustion during the sampling periods. Instantaneous concentration values for each species monitored were determined every five minutes by the CEM system.

Five types of process samples were taken during the MM5 test periods: strong black liquor, caustic (sodium hydroxide), white liquor, weak black liquor, and ClO_2 generation system by-product salt cake. The strong black liquor samples were taken to characterize dioxin/furan and dioxin/furan precursor contents of the material fed to the boiler. Three identical composites of hourly strong black liquor samples were prepared: one for dioxin/furan analysis by Troika, one for dioxin/furan precursor analysis by Radian/RTP, and one for total chloride analysis by Radian/Austin. The caustic, white liquor, weak black liquor, and ClO_2 generation system by-product salt cake samples were taken to indicate the major contributors of chloride to the mill liquor circuit. These samples were taken twice during each test day, and a single sample composite for each test run was sent to Radian/Austin for total chloride analysis.

Soil samples were collected from ten locations at the plant site. The ten samples were combined into a single composite, which was held for potential dioxin/furan analysis pending evaluation of the MM5 dioxin/furan emissions data.

4.2 PROCESS DATA COLLECTION

Process data were collected to characterize the operation of the black liquor boiler and electrostatic precipitator (ESP) during the MM5 test periods. A computer system in the black liquor boiler control room was used to print out a graphic display of boiler load, boiler exhaust gas oxygen content, black liquor solids content, and stack CO concentration during the test runs. In addition, hourly average steam flow, boiler O_2, combustion air flow and temperature, black liquor characteristics, ESP gas flow and temperature, and ESP exhaust gas composition data were printed out by the computer in hourly log reports. Electrostatic precipitator voltage and current data were recorded manually at intermittent times throughout the test period. The process data are used in Section 5.1 with the CEM data to evaluate and compare combustion conditions during the three MM5 test periods.

4.3 LABORATORY ANALYSES

Laboratory analyses performed on samples from test Site BLB-A included dioxin/furan analyses, dioxin/furan precursor analyses and chloride, sulfate, and sodium analyses. Samples analyzed for dioxin/furan are discussed in Section 4.3.1 and samples analyzed for dioxin precursors are discussed in Section 4.3.2. Samples analyzed for chloride (Cl^-) are discussed in Section 4.3.3.

4.3.1 Dioxin/Furan Analyses

All dioxin/furan analyses for Site 04 samples were performed by the EPA ECL-BSL and EMSL-RTP laboratories, two of the three laboratories collectively known as the Troika. Field samples requiring dioxin/furan analysis were prioritized by Tier 4 based on their relative importance to the Tier 4 program objectives. The priority levels, in order of decreasing importance, were designated Priority 1 through Priority 3.

Priority 1 samples were sent to Troika with instructions to perform immediate extraction and analysis. These included the MM5 train components for the electrostatic precipitator inlet and outlet sampling locations, and an MM5 train field blank.

Priority 2 samples sent to Troika were to be analyzed for dioxin/furan pending the results of the Priority 1 analyses. Priority 2 samples included only the strong black liquor samples.

Priority 3 samples included only the composite soil sample. The soil sample is being held by Radian's Research Triangle Park (RTP), N.C. laboratory pending evaluation of the Priority 1 and 2 analyses.

4.3.2 Dioxin/Furan Precursor Analysis

Dioxin/furan precursor analyses of strong black liquor samples were performed by Radian/RTP. The specific dioxin/furan analyzed for included chlorophenols, chlorobenzenes, PCB's and total chlorine.

4.3.3 Total Chloride Analysis

Chloride analysis was performed on the combined probe rinse/filter sample and on the back-half rinse/impinger solution sample for each HCL train (i.e., front-half and back-half analysis). Chloride analysis was also performed on the strong black liquor, caustic, white liquor, weak black liquor, and by-product salt cake.

5.0 TEST RESULTS

The results of the Tier 4 dioxin/furan emissions test of black liquor boiler BLB-A are presented in this section. The individual test runs are designated as Runs 1-3.

Process data obtained during the test runs are presented in Section 5.1, and flue gas parameter data are contained in Section 5.2. Continuous monitoring results for O_2, CO, CO_2, NO_x, SO_2, and THC are presented in Section 5.3. The dioxin/furan emissions data are contained in Section 5.4. Strong black liquor and dioxin/furan precursor analyses are presented in Section 5.5. Results of HCl train sampling at the electrostatic precipitator (ESP) outlet and chlorine analysis data of various process samples are presented in Sections 5.6 and 5.7.

5.1 PROCESS DATA

Process data were obtained to document black liquor boiler and electrostatic precipitator operation during the test runs. The boiler operating data are summarized in Section 5.1.1, and the electrostatic precipitator operating data are summarized in Section 5.1.2. In general, the data show that process operations were very stable during the three test runs.

5.1.1 Black Liquor Boiler Operating Data

Plant-maintained data summarizing the mean operating conditions of black liquor boiler BLB-A during the three MM5 test runs are shown in Table 5-1. Continuous data on boiler load, flue gas oxygen content in the economizer section of the boiler, strong black liquor solids content, and flue gas carbon monoxide content at the ESP outlet exhaust stack are shown for each run in Figures 5-1, 5-2, and 5-3. These data plots were generated for the dioxin/furan test program by a computer system in the black liquor boiler control room. The data show that the incinerator was operated similarly during the individual test runs. There were no process upsets during any of the runs that resulted in sampling interruptions. The one hour data gap in Figure 5-3 is due to a brief malfunction in the data acquisition system. The process was stable during this time period.

TABLE 5-1. MEAN VALUES[a] OF VARIOUS BOILER OPERATING PARAMETERS MONITORED BY HOST PLANT AT SITE BLB-A

Run	Boiler Load[b] (10^3lb/hr)	Boiler Oxygen[c] (%)	Black Liq. Flow (gpm)	Black Liq. % Solids (wt%)	Stack Oxygen[d] (%)	Stack CO[e] (ppmv)	Stack TRS[f] (ppmv @ 8% O_2)	Stack Opacity (%)
Run 1	389	4.1	256	65.6	6.4	3.7	4.0	15.0
Run 2	389	3.6	254	65.6	6.0	17	4.5	15.0
Run 3	389	3.1	264	63.7	5.5	65	3.5	15.0
Mean Value Runs 1-3	389	3.6	258	65.0	6.0	29	4.0	15.0

---

[a] Values shown in units used by host plant.

To convert from:	to:	multiply by:
lb/hr	kg/hr	0.454
gpm	cumeter/min	0.00379
psi	kPa	6.893
°R	°K	0.556

[b] Boiler load in 10^3lb/hr steam @ 914.7 psi, 1360°R (1452 Btu/lb)

[c] Boiler oxygen measured at economizer section (wet basis)

[d] Stack oxygen measured at ESP outlet stack (dry basis)

[e] Stack CO measured at ESP outlet stack (wet basis, O_2 as measured)

[f] Stack TRS measured at ESP outlet stack (dry basis, corrected to 8% O_2)

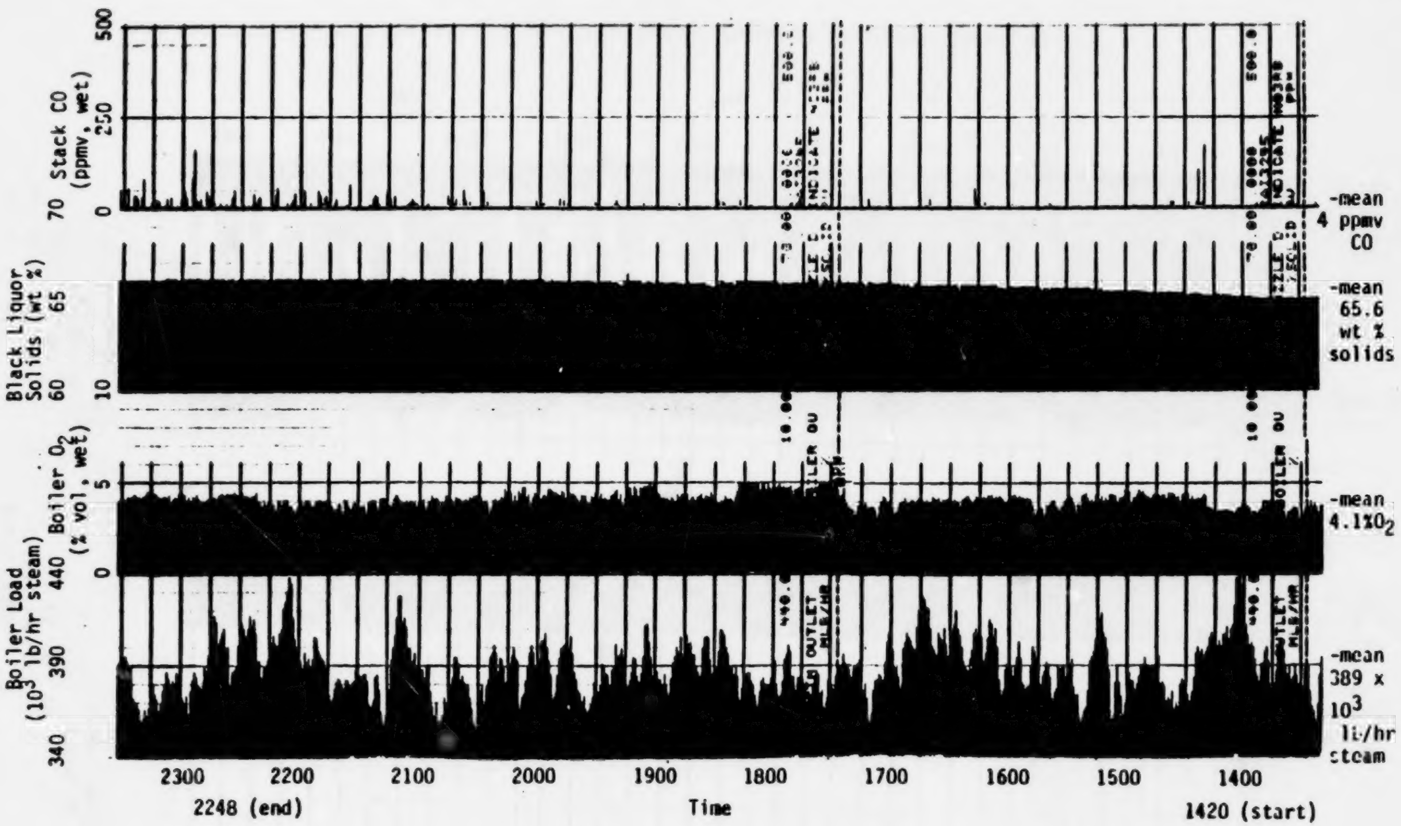

Figure 5-1. Continuously Monitored Boiler Operating Parameters During Run 1

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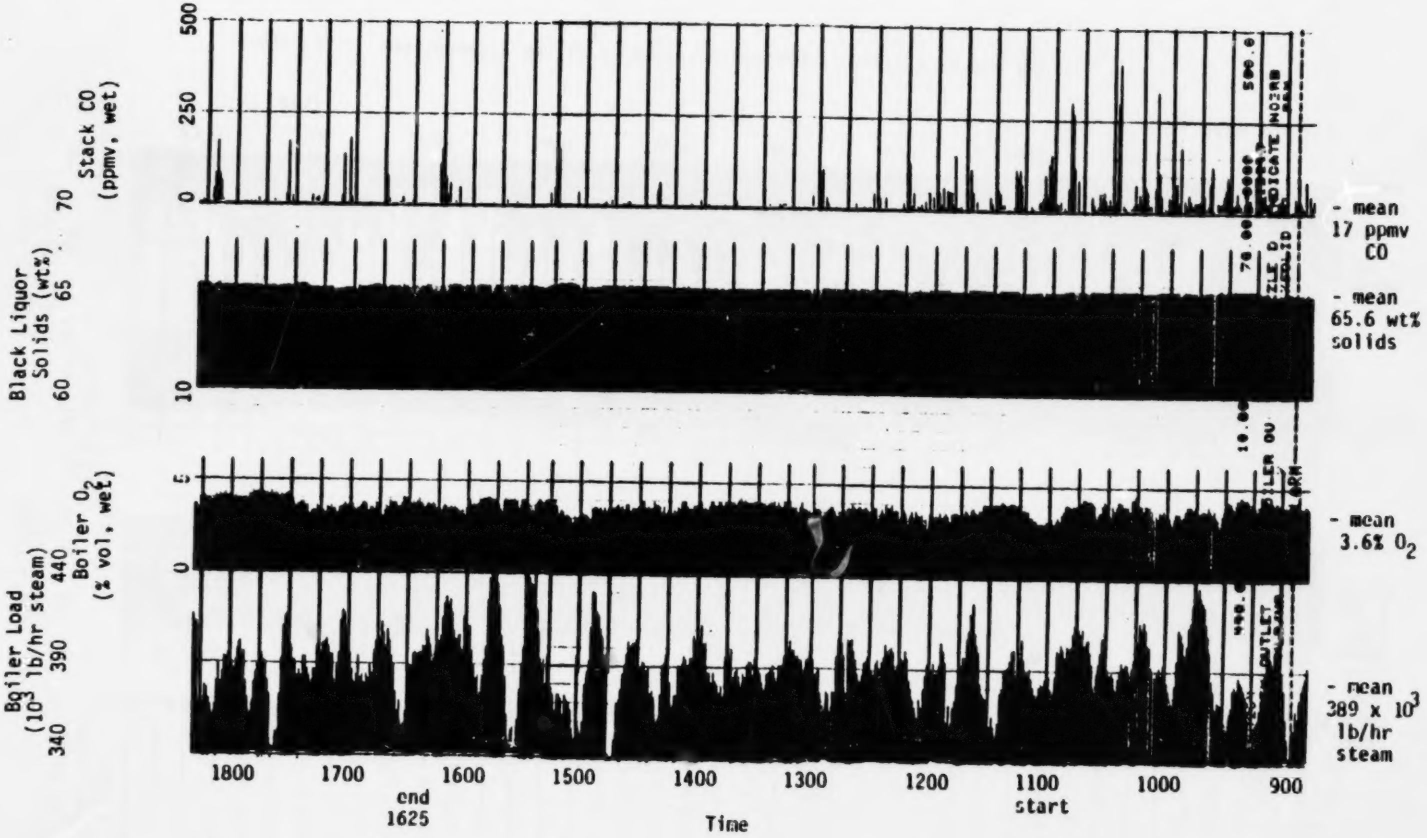


Figure 5-2 Continuously Monitored Boiler Operating Parameters During Run 2

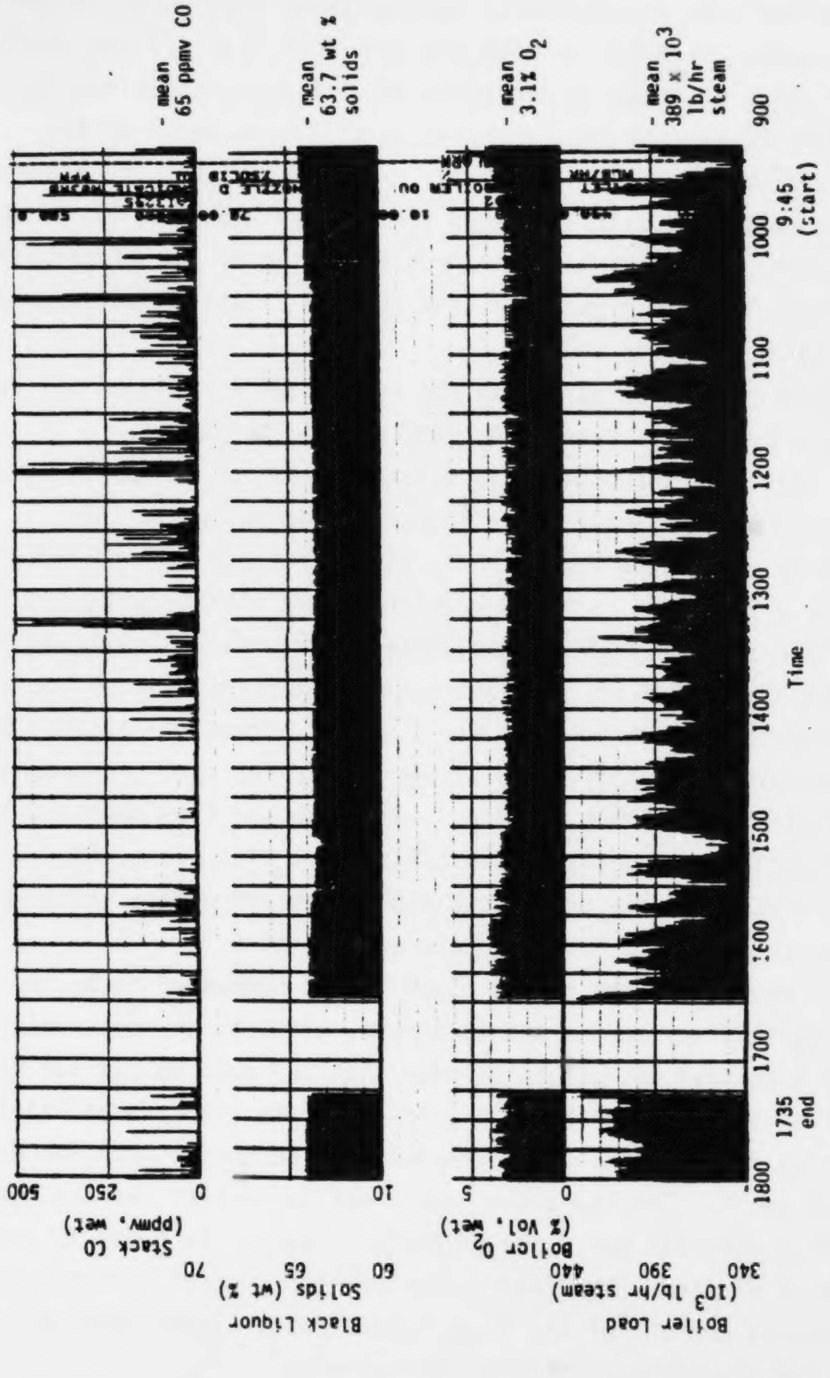


Figure 5-3. Continuously Monitored Boiler Operating Parameters During Run 3

The mean boiler load was identical for the three test runs: 176,000 kg/hr (389,000 lb/hr) steam corrected to 6305 kPa and 755^{o}K (915 psi and 1360^{o}R). The enthalpy of steam at these temperatures and pressure conditions is approximately 2210 kJ/kg (950 Btu/lb) relative to liquid water at the saturation temperature of the steam (552^{o}K, or 994^{o}F). Thus, the steam output of the boiler on an energy basis averaged 110 MW (370 MMBtu/hr) for each of the three test runs. The maximum within-run deviation of the instantaneous boiler load values shown in Figures 5-1 through 5-3 is approximately ±13 percent of the mean value for each run.

The mean flue gas oxygen values in the economizer section of boiler BLB-A were 4.1, 3.6, and 3.1 percent O_2 (wet basis) for Runs 1-3 respectively. This corresponds to mean excess air values of approximately 30, 25, and 21 percent respectively. The maximum deviation of the instantaneous flue gas oxygen values shown in Figures 5-1 through 5-3 is approximately ±1 percent O_2, which corresponds to a within-run excess air variability of approximately ±10 percent excess air. Carbon monoxide data generated by the host plant are consistent with the oxygen monitoring data and show typical inverse CO/O_2 behavior. Run 1, which showed the highest boiler flue gas oxygen value (4.1% O_2), also showed the lowest flue gas carbon monoxide value (4.6 ppmv @ 3% O_2). Run 3, which showed the lowest boiler flue gas oxygen value (3.1% O_2, wet), showed the highest flue gas carbon monoxide value (76 ppmv @ 3% O_2). The plant continuous monitoring data are compared with the Radian continuous monitoring data in Section 5.2.

The solids content of the strong black liquor combusted in boiler BLB-A showed little variability during the test runs, although the mean value for Run 3 (63.7 wt % solids) was slightly lower than the mean values for Runs 1 and 2 (65.6 wt % solids). The black liquor flow rate also showed little variability. The flow rate was approximately 3.5 percent higher for Run 3 than for Runs 1 and 2. The low black liquor solids content and the high black liquor flow rate for Run 3 are probably related. In order to produce a constant amount of steam, the feed forward boiler control system responded to the lower solids content of the black liquor (i.e., lower heating value) by increasing the black liquor flow to the burners.

The TRS monitoring data showed an average of 4.0 ppmv TRS @ 8% O_2, which is in compliance with the Federal New Source Performance Standard (NSPS) for black liquor boilers. TRS values did not seem to track other combustion-related parameters such as O_2 or CO. Stack opacity averaged 15.0 percent for each of the three test runs. The opacity values depend on electrostatic precipitator operation as well as combustion conditions in the boiler.

5.1.2 Electrostatic Precipitator Operating Data

Electrostatic precipitator (ESP) operating data maintained by the host plant are summarized in Table 5-2 for test runs 01, 02, and 03. The data show that the ESP was operated similarly during the three runs.

The ESP was set in the opacity control mode during each run, which is typical of normal operation at Site 04. Under the opacity control mode, the power supplied to the ESP is adjusted to maintain a stack outlet opacity of 15 percent. The total power consumption rate of the precipitation during the test runs was approximately 50 kw, split equally between the east and west halves of the unit. The mean outlet gas temperature ranged from 174^o to 175^o C (345^o to 347^o F), and the gas flow rates to the two halves of the unit were nearly identical. Opacity monitors stationed at the outlet from each half of the ESP varied considerably from east to west, but the east half and west half values were nearly constant between runs. Plant personnel were not certain whether the higher opacity values measured in the east half outlet were due to a difference in particulate matter removal efficiencies between the east and west halves, or whether the east half opacity monitor was not working correctly. In any event, the total stack opacity of the combined streams at the outlet exhaust stack was nearly constant at 15.0 percent. The low stack opacity values were consistent with visual observation.

The gas flow rate measured by Radian at the inlet to the ESP ranged from 7930 acmm to 8160 acmm (280,000 acfm to 288,000 acfm). Using a plate area of 17,150 m^2 (184,570 ft^2), this corresponds to a specific collection area of approximately 0.20 m^2/acmm (0.65 ft^2/acfm) which is higher than the design value of 0.16 m^2/acmm (0.5 ft^2/acfm).

TABLE 5-2. SUMMARY OF PLANT-MAINTAINED ELECTROSTATIC PRECIPITATOR OPERATING DATA FOR SITE BLB-A

Parameter	Run 01	Run 02	Run 03
Control Mode	Opacity Control	Opacity Control	Opacity Control
Gas Flow Rate			
1. East Precip Flow Indicator (10^3 acfm)	107	106	106
2. West Precip Flow Indicator (10^3 acfm)	110	108	109
Outlet Temperature			
3. East Precip Outlet Temperature (°F)	346	345	346
4. West Precip Outlet Temperature (°F)	347	345	346
Opacity			
5. East Precip Opacity (%)	25.7	24.8	24.7
6. West Precip Opacity (%)	13.0	13.9	13.6
7. Stack Opacity (%)	15.0	15.0	15.0
Power Consumption[a]			
8. East Precip (kw)	23.6	25.3	27.9
9. West Precip (kw)	26.6	28.5	24.6

[a] Power consumption numbers are based on limited data (7 voltage-current pairs during the 3 tests)

5.2 FLUE GAS PARAMETER DATA

Table 5-3 summarizes flue gas temperature, moisture, volumetric flowrate, and oxygen concentration data obtained at Site BLB-A. These parameters were fairly consistent among test runs. The average flue gas temperature and moisture content measured at the ESP inlet and outlet were 178°C, 27.8%, and 173°C, 24.8%, respectively. The average gas flowrates for the ESP inlet and outlet under actual stack temperature and moisture conditions were 8100 acmm (285,900 acfm) and 7,600 acmm (268,300 acfm), respectively. The average dry standard flowrate was 3,600 dscmm (127,100 dscfm) for the inlet and 3,700 dscmm (130,600 dscfm) for the outlet. Standard EPA conditions are 20°C (68°F) and 1 atm.

Flue gas oxygen concentration data were obtained from the plant O_2 analyzer, the Radian CEM system, and integrated bag samples (EPA Method 3). The average ESP inlet O_2 concentration of the flue gas measured by EPA Method 3, the Radian CEM, and the plant O_2 analyzer was 5.2, 6.0, and 4.8 vol%, respectively. The ESP outlet O_2 concentration was 5.0 vol%, as measured by EPA Method 3.

5.3 CONTINUOUS EMISSIONS MONITORING DATA

Mean values and standard deviations of the continuously monitored combustion gases at the ESP inlet location (O_2, CO, CO_2, SO_2, NO_x and THC) are shown for each MM5 test run in Table 5-4. The data show that most of the runs have similar mean concentration values for the individual gases. The overall mean values for the three test runs are as follows: oxygen, 6.0 percent by volume (dry); carbon monoxide, 136 ppmv (dry @ 3% O_2); carbon dioxide, 15.6 percent by volume (dry @ 3% O_2); sulfur dioxide, 94 ppmv (dry @ 3% O_2); nitrogen oxides, 83 ppmv (dry @ 3% O_2); and total hydrocarbons, 4 ppmv (wet @ 3% O_2, as propane).

The mean oxygen concentration measured by the Radian CEM system at the ESP inlet was fairly consistent between runs, but was slightly higher for Run 03 (6.5%) than for Runs 01 and 02 (5.9 and 5.7%, respectively). This was not consistent with the trend of the measured oxygen content data obtained by the plant at the economizer section of the boiler and at the stack. Table 5-5

TABLE 5-3. FLUE GAS PARAMETERS AT SITE BLB-A[a]

Flue Gas Parameter	Run 01 Inlet	Run 01 Outlet	Run 02 Inlet	Run 02 Outlet	Run 03 Inlet	Run 03 Outlet	Average Inlet	Average Outlet
Temperature (°C)	177.0	175.0	178.0	173.0	178.0	172.0	178.0	173.0
Moisture (Vol %)	25.0	24.9	27.0	23.9	31.5	25.7	27.8	24.8
Volumetric Flowrate								
Actual (acmm)	8200	7800	8100	7600	8000	7500	8100	7600
Dry standard (dscmm)	3800	3800	3700	3700	3400	3600	3600	3700
Oxygen Content (Vol%)								
EPA Method 3[b]	-	-	-	5.6	5.2	4.3	5.2	5.0
Radian CEM	5.9	-	5.7	-	6.5	-	6.0	-
Plant CEM[c]	5.5	6.4	4.8	6.0	4.1	5.5	4.8	6.0

[a] Metric units are reported for all of the flue gas measurement data. To convert to alternate units: °F = 1.8(°C) + 32; cfm = cmm x 35.5.

[b] Volume % concentration on a dry basis.

[c] The inlet values were measured at the economizer; adjusted to a dry basis using 25% H_2O. The outlet values were measured at the stack; reportd on a wet basis.

TABLE 5-4. MEAN VALUES AND STANDARD DEVIATIONS OF CONTINUOUSLY MONITORED COMBUSTION GASES DURING DIOXIN/FURAN TESTS AT SITE BLB-A

Parameter[a]	Run 01	Run 02	Run 03	Overall Mean
O_2 (% vol)	5.9 (0.3)	5.7 (0.4)	6.5 (0.5)	6.0
CO (ppmv @ 3% O_2)	84.4 (65.2)	159.4 (79.4)	165.5 (149.2)	136.4
CO_2 (% Vol @ 3% O_2)	16.3 (0.8)	14.7 (1.3)	15.9 (1.4)	15.6
SO_2 (ppmv @ 3% O_2)	112.1 (102.1)	54.1 (43.0)	117.0 (85.2)	94.4
NO_x (ppmv @ 3% O_2)	75.1 (7.4)	89.1 (4.5)	85.4 (4.3)	83.2
THC (ppmv @ 3% O_2)	2.9 (3.6)	2.8 (2.2)	4.8 (6.5)	11.9

[a] All concentrations expressed on a dry volume basis except for total hydrocarbon concentrations, which are expressed on a wet volume basis.

[b] Total hydrocarbon data are expressed in units of ppmv (wet) as propane.

summarizes the Radian CEM data at the ESP inlet location, the Radian Method 3 data at the ESP inlet and stack outlet locations, the plant CEM data at the economizer section of the boiler and the plant CEM data at the outlet stack location. While the data are not conclusive, it appears that a minor leakage may have developed in the Radian CEM sampling system during the tests.

Instantaneous concentration values obtained at 5-minute intervals for each of the continuously monitored combustion gases are tabulated in Appendix A-2 and are shown graphically as functions of time in Figures 5-4 through 5-9. These graphs show that in general the measured O_2 and NO_x values were fairly constant within runs. The CO and CO_2 data show considerable random scatter, much of which is attributable to instrument noise. However, the CO data do verify the trend toward higher CO levels for Runs 02 and 03 than for Run 01, as was also indicated by the plant CO monitor at the stack. The THC data do not seem to track either O_2 or CO data. THC peaks in the 20 ppm range were observed for each test run, but these peaks could not be correlated with variations in process conditions in the boiler.

The SO_2 data show a distinctive cyclical behavior which is believed to be associated with the make-up sulfur addition rate in the black liquor mix tank. Peaks as high as 400 ppmv SO_2 @ 3% O_2 were observed during Runs 01 and 03, with lower peaks observed during Run 02.

5.4 MM5 DIOXIN/ FURAN EMISSIONS DATA

5.4.1 Electrostatic Precipitator Inlet

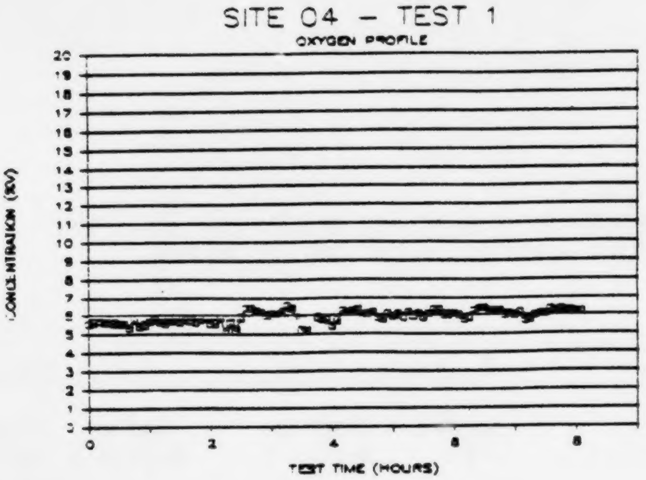
Emission concentrations and emissions rate data measured at the electrostatic precipitator (ESP) inlet are shown in Table 5-6 and 5-7 for the 2378 TCDD, total PCDD, and total PCDF species. The data include dioxin and furan collection in the entire MM5 train, including filter, XAD sorbent trap, impingers, and sample train clean-up rinses.

Average as-measured ESP inlet concentrations of total PCDD, and PCDF species were 1.58 ng/dscm total PCDD and 1.31 ng/dscm total PCDF. When corrected to 3% O_2 using the Radian CEM oxygen concentration data, these values correspond to 1.79 ng/dscm @ 3% O_2 and 1.47 ng/dscm @ 3% O_2, respectively. Average emission rates were 340 ug/hr total PCDD, and 280 ug/hr

TABLE 5-5. COMPARISON OF MEASURED OXYGEN CONCENTRATION VALUES (VARIOUS LOCATIONS AND METHODS)

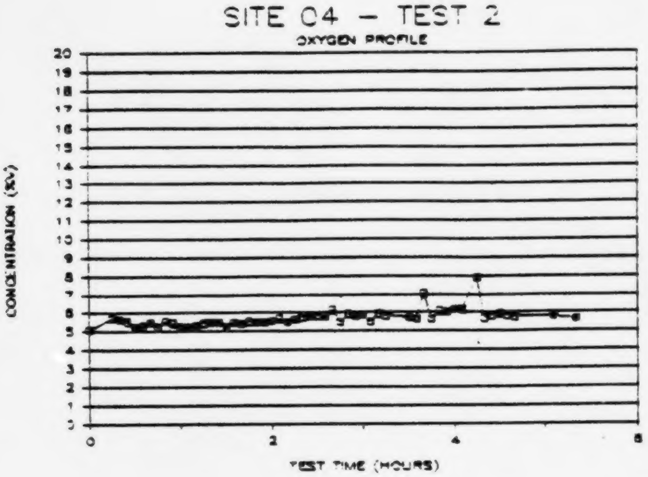
Run Number	Economizer		Precipitator Inlet		Outlet Stack	
	Plant CEM at Economizer (wet)	Plant CEM at Economizer (dry)[a]	Radian CEM	Radian Method 3	Radian Method 3	Plant CEM at stack
01	4.1	5.5	5.9	-	-	6.4
02	3.6	4.8	5.7	-	5.6	6.0
03	3.1	4.1	6.5	5.2	4.3	5.5

[a] Assuming 25% moisture.



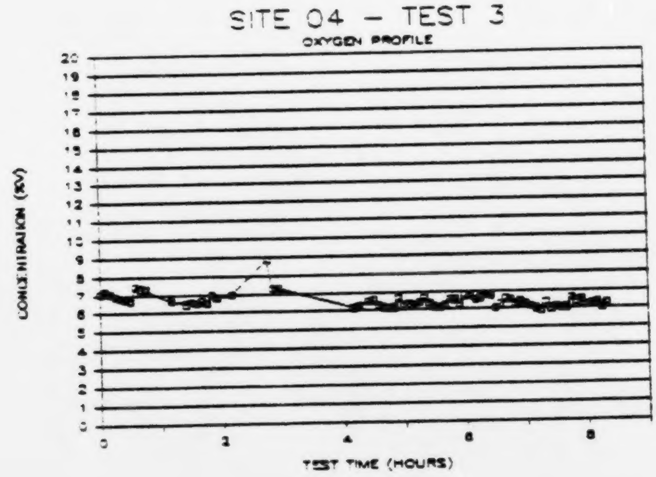
mean = 5.9% O_2

std dev = 0.3 % O_2



mean = 5.7% O_2

std dev. = 0.4% O_2



mean = 6.5% O_2

std dev. = 0.5% O_2

Figure 5-4 Oxygen Concentration History at the Electrostatic Precipitator Inlet Location (dry vol %)

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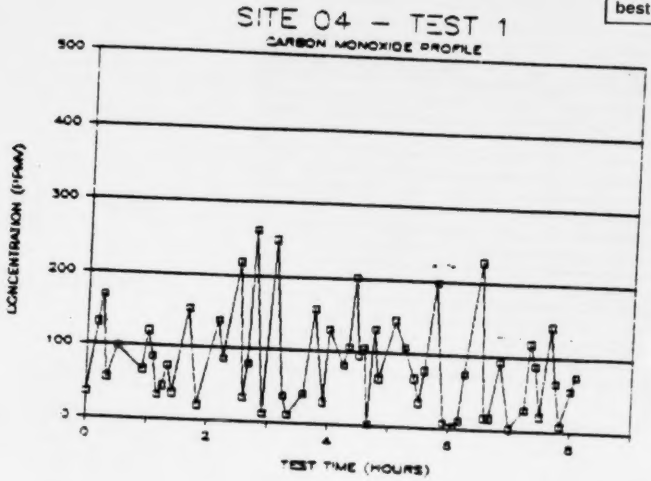
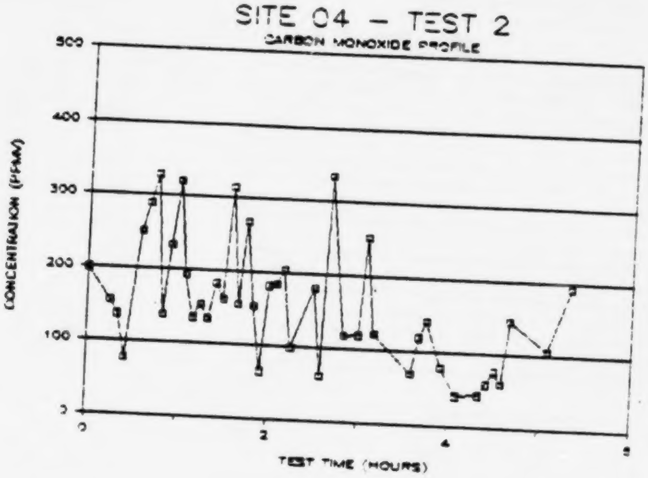


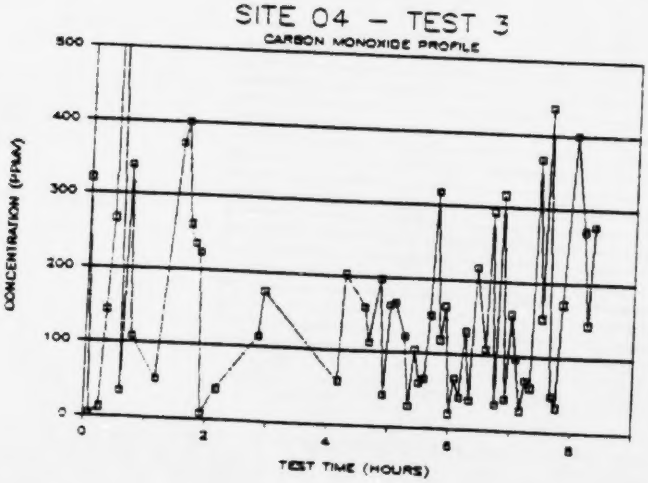
mean = 84.4 ppmv CO
@ 3% O_2

std dev = 65.2 ppmv CO
@ 3% O_2



mean = 159.4 ppmv CO
@ 3% O_2

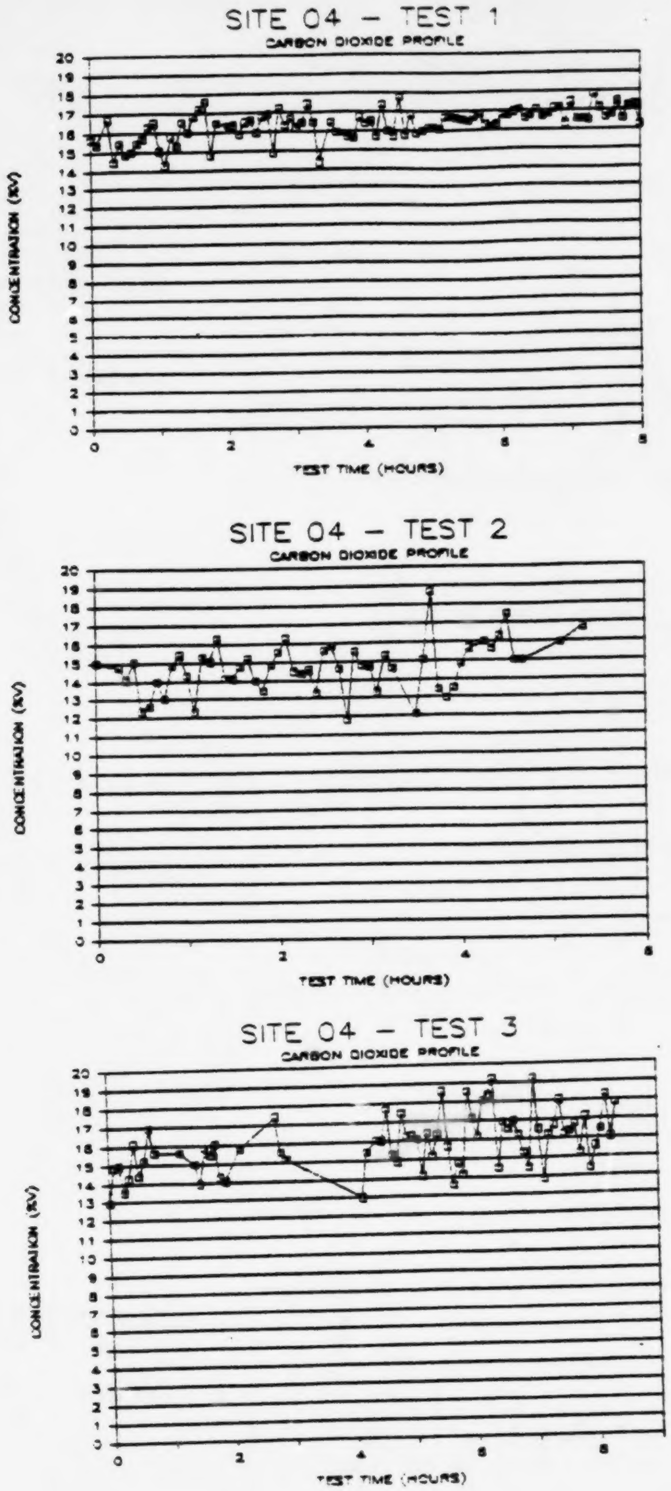
std dev = 79.4 ppmv CO
@ 3% O_2



mean = 165.5 ppmv CO
@ 3% O_2

std dev = 149.2 ppmv CO
@ 3% O_2

Figure 5-5. Carbon Monoxide Concentration History at the Electrostatic Precipitator Inlet Location (dry ppmv @ 3% O_2)



mean = 16.3% CO_2 @3% O_2

std dev = 0.8% CO_2 @3% O_2

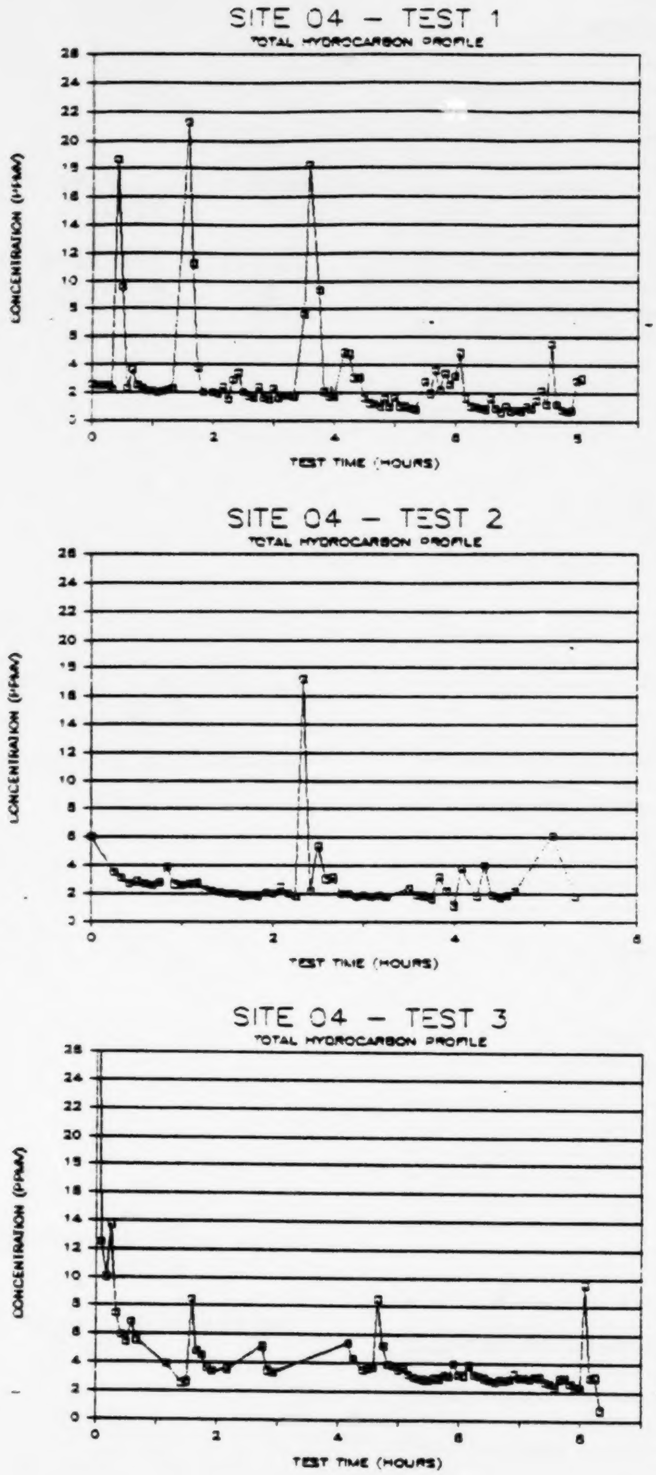
mean = 14.7% CO_2 @3% O_2

std dev = 1.3% CO_2 @ 3% O_2

mean = 15.9% CO_2 @3% O_2

std dev = 1.4% CO_2 @ 3% O_2

Figure 5-6 Carbon Dioxide Concentration History at the Electrostatic Precipitator Inlet Location (dry vol % @ 3% O_2)



mean = 2.9 ppmv THC
@ 3% O_2

std dev = 3.6 ppmv THC
@ 3% O_2

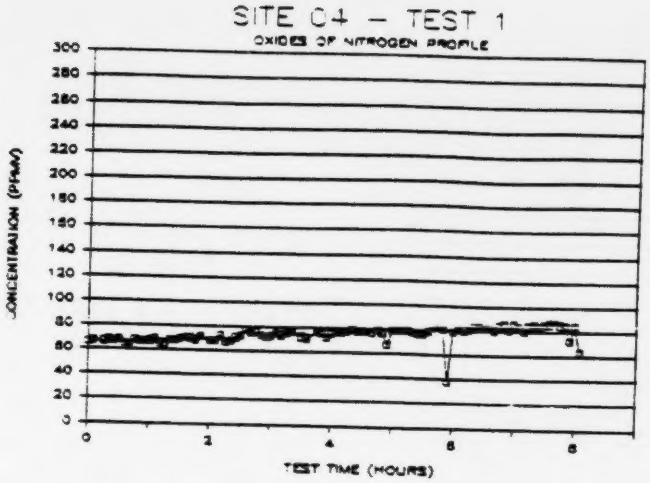
mean = 2.8 ppmv THC
@ 3% O_2

std dev = 2.2 ppmv THC
@ 3% O_2

mean = 4.8 ppmv THC
@ 3% O_2

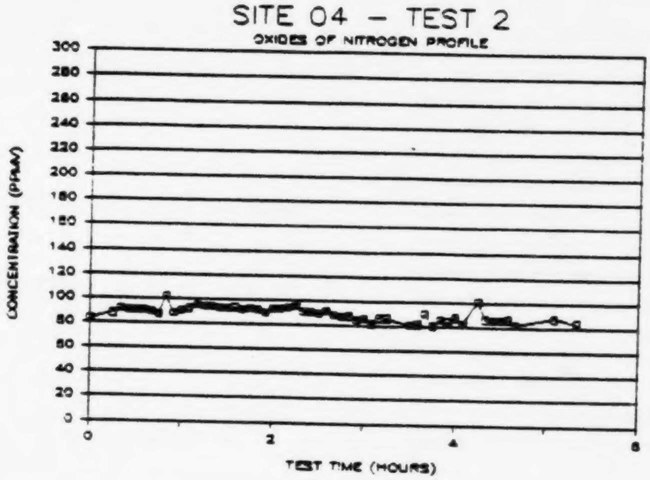
std dev = 6.5 ppmv THC
@ 3% O_2

Figure 5-7 Total Hydrocarbon Concentration History at the Electrostatic Precipitator Inlet Location (wet ppmv as propane @ 3% O_2)



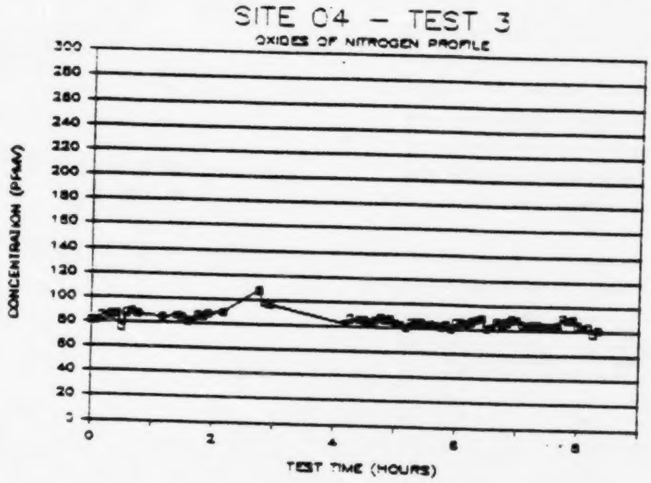
mean = 75.1 ppmv NO_x @ 3% O_2

std dev = 7.4 ppmv NO_x @ 3% O_2



mean = 89.1 ppmv NO_x @ 3% O_2

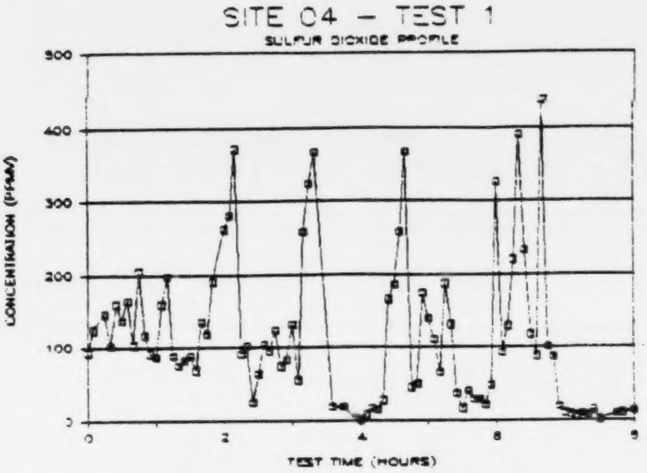
std dev = 4.5 ppmv NO_x @ 3% O_2



mean = 85.4 ppmv NO_x @ 3% O_2

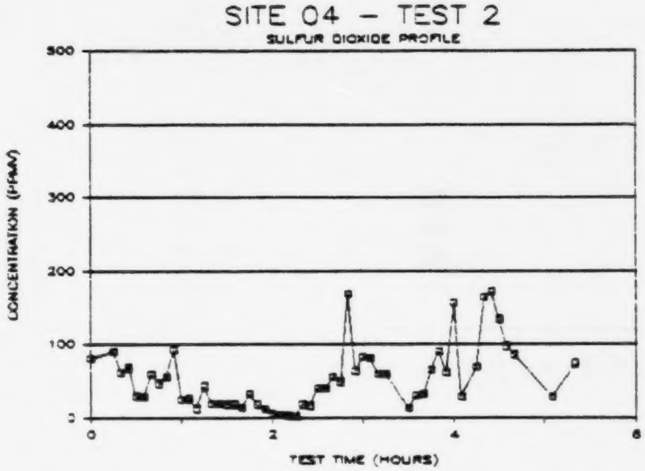
std dev = 4.3 ppmv NO_x @ 3% O_2

Figure 5-8 Nitrogen Oxides Concentration History at the Electrostatic Precipitator Inlet Location (dry ppmv @ 3% O_2)



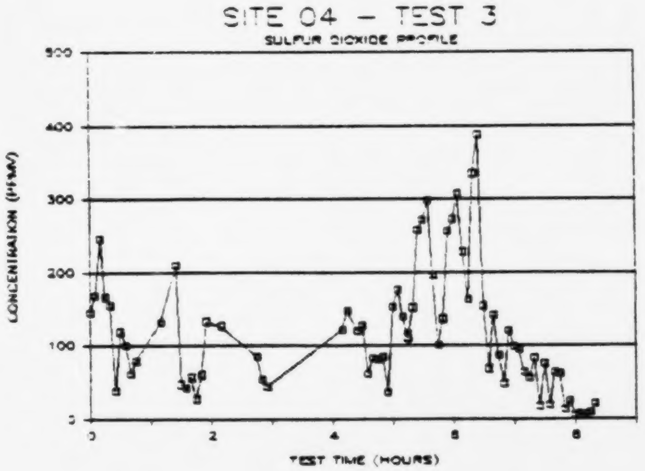
mean = 112.1 ppmv SO_2 @ 3% O_2

std dev = 102.1 ppmv SO_2 @ 3% O_2



mean = 54.1 ppmv SO_2 @ 3% O_2

std dev = 43.0 ppmv SO_2 @ 3% O_2



mean = 117.0 ppmv SO_2 @ 3% O_2

std dev = 85.2 ppmv SO_2 @ 3% O_2

Figure 5-9 Sulfur Dioxide Concentration History at the Electrostatic Precipitator Inlet Location (dry ppmv @ 3% O_2)

TABLE 5-6. OVERVIEW OF DIOXIN/FURAN EMISSIONS CONCENTRATION DATA FOR SITE BLB-A (ELECTROSTATIC PRECIPITATOR INLET)

Run Number	2378 TCDD	Total PCDD	Total PCDF
Emissions Concentration (as measured), ng/dscm			
Run 01	ND	1.21	1.31
Run 02	ND	0.93	1.03
Run 03	ND	2.61	1.58
Average	--	1.59	1.31
Emissions Concentration (corrected to 3% O_2), ng/dscm @ 3% O_2			
Run 01	ND	1.37	1.47
Run 02	ND	1.05	1.16
Run 03	ND	2.94	1.77
Average	--	1.79	1.47

ND = not detected. See Tables 5-8 and 5-9 for detection limits.

TABLE 5-7. SUMMARY OF DIOXIN AND FURAN EMISSIONS RATE DATA FOR SITE BLB-A (ELECTROSTATIC PRECIPITATOR INLET)

Run Number	Dioxin/Furan Emission Rate, ug/hr 2378 TCDD	 Total PCDD	 Total PCDF
Run 01	ND	280	302
Run 02	ND	206	228
Run 03	ND	530	320
Average	--	339	283

ND = not detected. See Table 5-8 for detection limits.

total PCDF. ~~Emissions of~~ 2378 TCDD was not detectable. ~~were consistently below the detection limit.~~ The total PCDD and PCDF emissions were fairly consistent between runs. The maximum deviation of any individual run from the overall average was approximately 56 percent for total PCDD emissions and 19 percent for total PCDF emissions.

Isomer and homologue-specific emission concentration data are summarized in Table 5-8 and 5-9 for the three test runs. Run-specific data tables showing homologue emission concentrations in both ng/dscm and parts-per-trillion units and homologue emission rates in ug/hr units are included in Appendix D. Detectable quantities were found for roughly two-thirds of the isomers and homologues analyzed for at the ESP inlet of Site BLB-A. Figure 5-10 is a histogram that shows the relative distributions of the 2378 TCDD/TCDF isomers and the tetra- through octa-PCDD/PCDF homologues in the inlet ESP emissions (mole basis). The distribution of dioxin species was extremely non-uniform among the various homologues. Only the hepta- and octa-CDD homologues were consistently detectable in the ESP inlet emissions. The octa-CDD homologue accounted for roughly 80 percent of the total dioxins detected. The hepta-CDD homologues accounted for the remaining 20 percent of the total dioxins in the ESP inlet emissions. The furan species were more uniformly distributed than the dioxin species, with the hepta-CDF homologue being the largest single contributor to the total PCDF emissions. The contributions of the tetra- through octa-chlorinated furan homologues to the total PCDF were: tetra, 19-26%; penta, 0-24%; hexa, 33-50%; hepta, 12-24%; and octa, 0-8%.

Emission factors for the ESP inlet at site BLB-A are shown in Table 5-10. Average emission factors for total PCDD and total PCDF were 0.006 ug total PCDD emitted per Kg feed and 0.005 ug total PCDF emitted per Kg feed (dry solids feed basis). Emission factors for the various dioxin and furan homologues varied considerably between runs.

TABLE 5-8. SUMMARY OF DIOXIN/FURAN EMISSIONS DATA FOR SITE BLB-A INLET (AS-MEASURED CONCENTRATIONS)

Dioxin/Furan Isomer	Isomer Concentration in Flue Gas (ng/dscm) Run 01	Run 02	Run 03	Avg.
DIOXINS				
2378 TCDD	ND(1.94E-02)	ND(1.98E-02)	ND(7.47E-02)	.00E+00
Other TCDD	ND(1.94E-02)	1.98E-02	ND(7.47E-02)	6.61E-03
Penta-CDD	ND(7.52E-02)	ND(2.38E-02)	ND(9.96E-02)	.00E+00
Hexa-CDD	1.21E-01	7.94E-02	ND(3.90E-01)	6.69E-02
Hepta-CDD	2.91E-01	1.98E-01	5.81E-01	3.57E-01
Octa-CDD	8.01E-01	6.35E-01	2.03E+00	1.16E+00
Total PCDD	1.21E+00	9.33E-01	2.61E+00	1.59E+00
FURANS				
2378 TCDF	ND(1.46E-02)	ND(7.94E-02)	ND(1.66E-01)	.00E+00
Other TCDF	2.43E-01	1.98E-01	4.15E-01	2.85E-01
Penta-CDF	3.16E-01	2.38E-01	ND(6.14E-01)	1.85E-01
Hexa-CDF	4.37E-01	3.97E-01	7.88E-01	5.41E-01
Hepta-CDF	2.43E-01	1.19E-01	3.73E-01	2.45E-01
Octa-CDF	7.28E-02	7.94E-02	ND(2.61E-01)	5.07E-02
Total PCDF	1.31E+00	1.03E+00	1.58E+00	1.31E+00

NOTE: Isomer concentrations shown are at as-measured oxygen conditions.

ND = not detected (detection limit in parentheses).
ng = 1.0E-09g
8760 operating hours per year

TABLE 5-9. SUMMARY OF DIOXIN/FURAN EMISSIONS DATA FOR SITE BLB-A INLET (CONCENTRATIONS CORRECTED TO 3 PERCENT OXYGEN)

Dioxin/Furan Isomer	Isomer Concentration in Flue Gas (ng/dscm @ 3% oxygen)			
	Run 01	Run 02	Run 03	Avg.
DIOXINS				
2378 TCDD	ND(2.18E-02)	ND(2.23E-02)	ND(8.40E-02)	.00E+00
Other TCDD	ND(2.18E-02)	2.23E-02	ND(8.40E-02)	7.44E-03
Penta-CDD	ND(8.46E-02)	ND(2.68E-02)	ND(1.12E-01)	.00E+00
Hexa-CDD	1.37E-01	8.93E-02	ND(4.39E-01)	7.53E-02
Hepta-CDD	3.28E-01	2.23E-01	6.54E-01	4.01E-01
Octa-CDD	9.01E-01	7.14E-01	2.29E+00	1.30E+00
Total PCDD	1.37E+00	1.05E+00	2.94E+00	1.79E+00
FURANS				
2378 TCDF	ND(1.64E-02)	ND(8.93E-02)	ND(1.87E-01)	.00E+00
Other TCDF	2.73E-01	2.23E-01	4.67E-01	3.21E-01
Penta-CDF	3.55E-01	2.68E-01	ND(6.91E-01)	2.08E-01
Hexa-CDF	4.92E-01	4.46E-01	8.87E-01	6.08E-01
Hepta-CDF	2.73E-01	1.34E-01	4.20E-01	2.76E-01
Octa-CDF	8.19E-02	8.93E-02	ND(2.94E-01)	5.71E-02
Total PCDF	1.47E+00	1.16E+00	1.77E+00	1.47E+00

NOTE: Isomer concentrations shown are corrected to 3% oxygen.

ND = not detected (detection limit in parentheses).
ng = 1.0E-09g
8760 operating hours per year

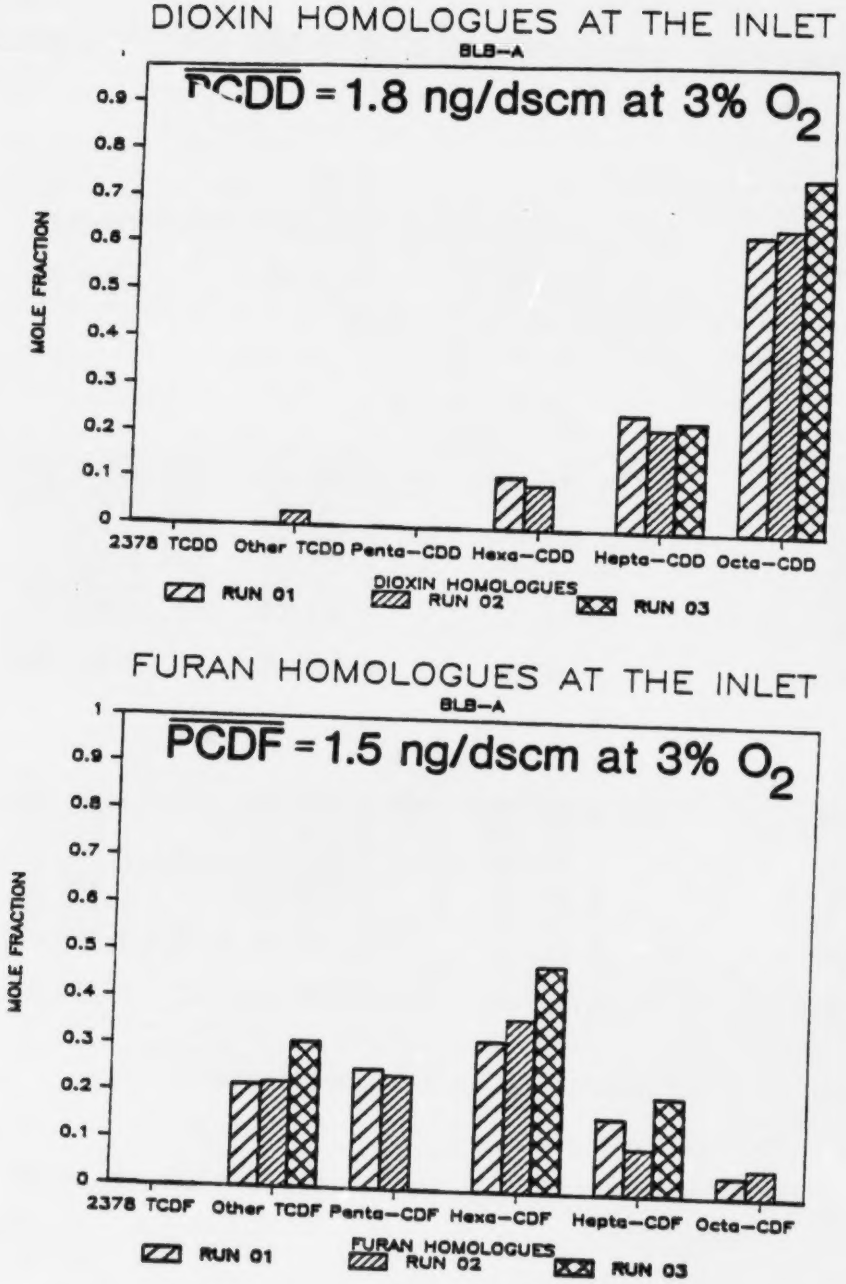


Figure 5-10. Dioxin and furan homologue distributions of the electrostatic precipitator inlet emissions for Site BLB-A.

TABLE 5-10. DIOXIN/FURAN EMISSION FACTORS FOR SITE BLB-A INLET

Dioxin/Furan Isomer	Dioxin/Furan Emission Factors (ug/kg)			
	Run 01	Run 02	Run 03	Avg.
DIOXINS				
2378 TCDD	ND(8.28E-05)	ND(8.18E-05)	ND(2.80E-04)	.00E+00
Other TCDD	ND(8.28E-05)	8.18E-05	ND(2.80E-04)	2.73E-05
Penta-CDD	ND(3.21E-04)	ND(9.81E-05)	ND(3.73E-04)	.00E+00
Hexa-CDD	5.18E-04	3.27E-04	ND(1.46E-03)	2.82E-04
Hepta-CDD	1.24E-03	8.18E-04	2.18E-03	1.41E-03
Octa-CDD	3.42E-03	2.62E-03	7.62E-03	4.55E-03
Total PCDD	5.18E-03	3.84E-03	9.80E-03	6.27E-03
FURANS				
2378 TCDF	ND(6.21E-05)	ND(3.27E-04)	ND(6.22E-04)	.00E+00
Other TCDF	1.04E-03	8.18E-04	1.55E-03	1.14E-03
Penta-CDF	1.35E-03	9.81E-04	ND(2.30E-03)	7.76E-04
Hexa-CDF	1.86E-03	1.64E-03	2.95E-03	2.15E-03
Hepta-CDF	1.04E-03	4.91E-04	1.40E-03	9.75E-04
Octa-CDF	3.11E-04	3.27E-04	ND(9.80E-04)	2.13E-04
Total PCDF	5.59E-03	4.25E-03	5.91E-03	5.25E-03

ND = not detected (detection limit in parentheses).
ug = 1.0E-06g
8760 operating hours per year

NOTE: Emission factors were calculated using the black liquor dry solids feed rate.

5.4.2 Electrostatic Precipitator Outlet

Emission concentrations and emissions rate data measured at the electrostatic precipitator (ESP) outlet are shown in Tables 5-11 and 5-12 for the 2378 TCDD, total PCDD, and total PCDF species. The data include dioxin and furan collected in the entire MM5 train, including filter, primary XAD sorbent trap, impingers, and sample train clean-up rinses.

Average as-measured outlet emission concentrations of total PCDD and PCDF were 0.67 ng/dscm total PCDD and 0.51 ng/dscm total PCDF. When corrected to 3% O_2 using the EPA Method 3 oxygen concentration data, these values correspond to 0.75 ng/dscm @ 3% O_2 and 0.57 ng/dscm @ 3% O_2, respectively. Average emission rates were 150 ug/hr total PCDD, and 110 ug/hr total PCDF. Emissions of 2378 TCDD were non-detectable for all three runs. The total PCDD and PCDF outlet emissions showed considerable variability between runs. The maximum deviation of any individual run from the overall average was approximately 80 percent for total PCDD and PCDF emissions.

Isomer and homologue specific outlet emission concentration data are summarized in Tables 5-13 and 5-14 for the three test runs. Run-specific data tables showing homologue emission concentrations in ng/dscm and parts-per-trillion units and homologue emission rates in ug/hr units are included in Appendix D. Detectable quantities were found for roughly half of the isomers and homologues analyzed for at the ESP outlet of Site BLB-A. Figure 5-11 is a histogram that shows the relative distributions of the 2378 TCDD/TCDF isomers and the tetra- through octa- PCDD/PCDF homologues in the ESP outlet emissions (mole basis). The distribution of dioxin species was non-uniform among the various homologues. Only the hepta and octa-CDD homologues were consistently detectable in the ESP outlet emissions. The octa-CDD homologue accounted for roughly 70 percent of the total dioxins found while the hexa-CDD isomer accounted for most of the remaining PCDD. The total PCDF emissions were more evenly distributed than the dioxin species with the contributions of the tetra- through octa-chlorinated furan homologues to the total PCDF being as follows: tetra, 10-33%; penta, 0-11%; hexa, 0-15%; hepta, 22-50%; and octa, 9-50%.

Emission factors for the ESP outlet at site BLB-A are shown in Table 5-15. Average outlet emission factors for total PCDD and total PCDF

TABLE 5-11. OVERVIEW OF DIOXIN AND FURAN EMISSIONS CONCENTRATION DATA FOR SITE BLB-A (ELECTROSTATIC PRECIPITATOR OUTLET)

Run Number	2378 TCDD	Total PCDD	Total PCDF
Emissions Concentration (as measured), ng/dscm			
Run 01	ND	1.18	0.89
Run 02	ND	0.51	0.52
Run 03	ND	0.31	0.10
Average	--	0.67	0.51
Emissions Rate Concentration (corrected to 3% O_2), ng/dscm @ 3% O_2			
Run 01	ND	1.33	1.00
Run 02	ND	0.59	0.61
Run 03	ND	0.33	0.11
Average	--	0.75	0.57

TABLE 5-12. SUMMARY OF DIOXIN AND FURAN EMISSIONS RATE DATA FOR SITE BLB-A (ELECTROSTATIC PRECIPITATOR OUTLET)

Run Number	Dioxin/Furan Emission Rate, ug/hr 2378 TCDD	 Total PCDD	 Total PCDF
Run 01	ND	268	202
Run 02	ND	113	117
Run 03	ND	68	22
Average	--	150	114

TABLE 5-13. SUMMARY OF DIOXIN/FURAN EMISSIONS DATA FOR SITE BLB-A OUTLET (AS-MEASURED CONCENTRATIONS)

Dioxin/Furan Isomer	Isomer Concentration in Flue Gas (ng/dscm)			
	Run 01	Run 02	Run 03	Avg.
DIOXINS				
2378 TCDD	ND(6.00E-02)	ND(1.69E-02)	ND(1.88E-02)	.00E+00
Other TCDD	ND(6.00E-02)	5.06E-02	ND(1.88E-02)	1.69E-02
Penta-CDD	ND(2.51E-02)	ND(2.02E-02)	ND(3.77E-02)	.00E+00
Hexa-CDD	1.55E-01	ND(5.40E-02)	ND(4.11E-02)	5.16E-02
Hepta-CDD	3.09E-01	8.43E-02	8.56E-02	1.60E-01
Octa-CDD	7.16E-01	3.71E-01	2.23E-01	4.36E-01
Total PCDD	1.18E+00	5.06E-01	3.08E-01	6.65E-01
FURANS				
2378 TCDF	ND(7.74E-03)	ND(3.37E-02)	ND(1.71E-02)	.00E+00
Other TCDF	3.29E-01	5.06E-02	3.42E-02	1.38E-01
Penta-CDF	1.55E-01	ND(3.88E-02)	ND(2.23E-02)	5.16E-02
Hexa-CDF	1.35E-01	5.06E-02	ND(8.73E-02)	6.20E-02
Hepta-CDF	1.93E-01	1.69E-01	5.14E-02	1.38E-01
Octa-CDF	7.74E-02	2.53E-01	1.71E-02	1.16E-01
Total PCDF	8.90E-01	5.23E-01	1.03E-01	5.05E-01

NOTE: Isomer concentrations shown are at as-measured oxygen conditions.

ND = not detected (detection limit in parentheses).
ng = 1.0E-09g
8760 operating hours per year

TABLE 5-14. SUMMARY OF DIOXIN/FURAN EMISSIONS DATA FOR SITE BLB-A OUTLET (CONCENTRATIONS CORRECTED TO 3 PERCENT OXYGEN)

Dioxin/Furan Isomer	Isomer Concentration in Flue Gas (ng/dscm @ 3% oxygen) Run 01	Run 02	Run 03	Avg.
DIOXINS				
2378 TCDD	ND(6.75E-02)	ND(1.97E-02)	ND(2.03E-02)	.00E+00
Other TCDD	ND(6.75E-02)	5.91E-02	ND(2.03E-02)	1.97E-02
Penta-CDD	ND(2.83E-02)	ND(2.37E-02)	ND(4.05E-02)	.00E+00
Hexa-CDD	1.74E-01	ND(6.31E-02)	ND(4.42E-02)	5.80E-02
Hepta-CDD	3.48E-01	9.86E-02	9.21E-02	1.80E-01
Octa-CDD	8.05E-01	4.34E-01	2.40E-01	4.93E-01
Total PCDD	1.33E+00	5.91E-01	3.32E-01	7.50E-01
FURANS				
2378 TCDF	ND(8.70E-03)	ND(3.94E-02)	ND(1.84E-02)	.00E+00
Other TCDF	3.70E-01	5.91E-02	3.68E-02	1.55E-01
Penta-CDF	1.74E-01	ND(4.53E-02)	ND(2.40E-02)	5.80E-02
Hexa-CDF	1.52E-01	5.91E-02	ND(9.40E-02)	7.05E-02
Hepta-CDF	2.18E-01	1.97E-01	5.53E-02	1.57E-01
Octa-CDF	8.70E-02	2.96E-01	1.84E-02	1.34E-01
Total PCDF	1.00E+00	6.11E-01	1.11E-01	5.74E-01

NOTE: Isomer concentrations shown are corrected to 3% oxygen.

ND = not detected (detection limit in parentheses).
ng = 1.0E-09g
8760 operating hours per year

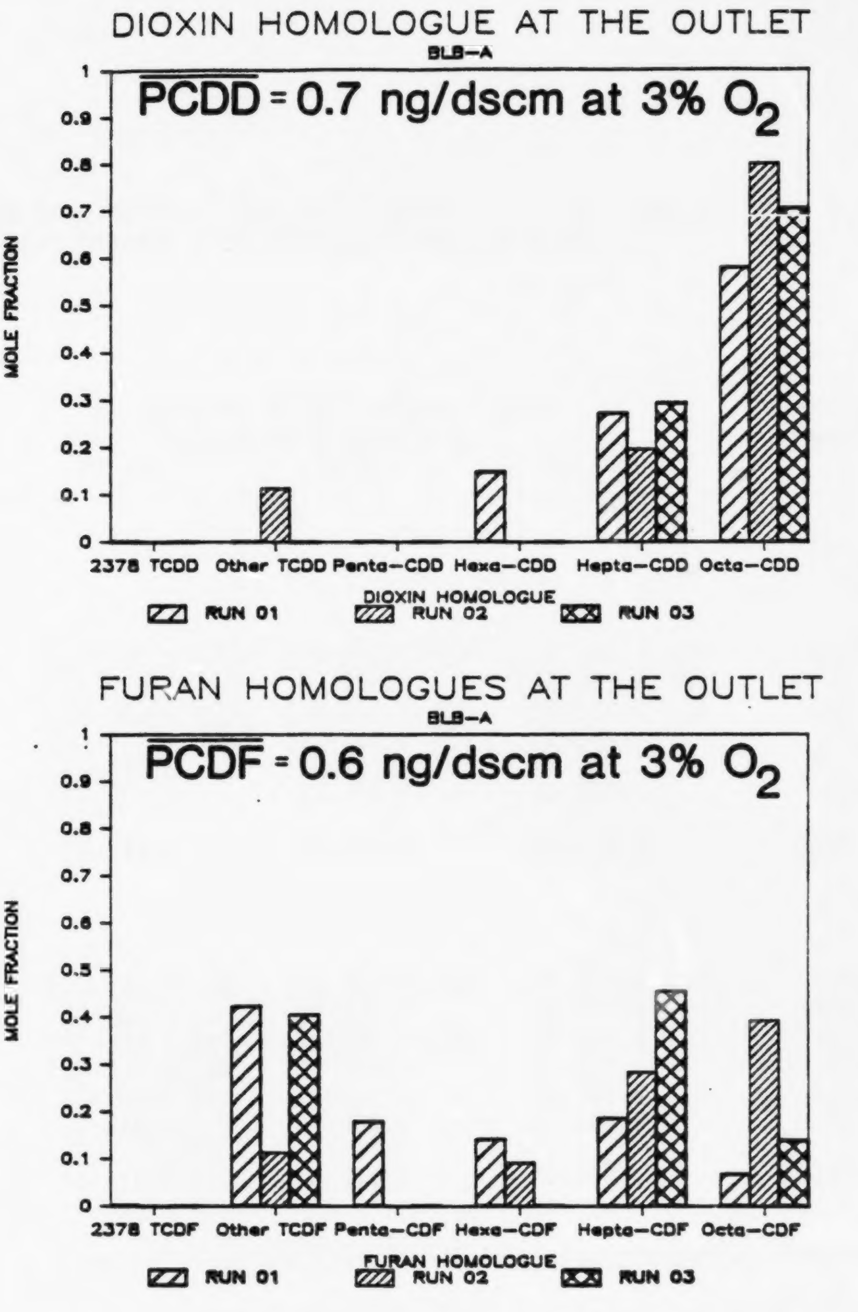


Figure 5-11. Dioxin and furan homologue distributions of the electrostatic precipitator outlet emissions for Site BLB-A.

TABLE 5-15. DIOXIN/FURAN EMISSION FACTORS FOR SITE BLB-A OUTLET

Dioxin/Furan Isomer	Dioxin/Furan Emission Factors (ug/kg)			
	Run 01	Run 02	Run 03	Avg.
DIOXINS				
2378 TCDD	ND(2.52E-04)	ND(7.06E-05)	ND(7.54E-05)	.00E+00
Other TCDD	ND(2.52E-04)	2.12E-04	ND(7.54E-05)	7.06E-05
Penta-CDD	ND(1.06E-04)	ND(8.47E-05)	ND(1.51E-04)	.00E+00
Hexa-CDD	6.51E-04	ND(2.26E-04)	ND(1.64E-04)	2.17E-04
Hepta-CDD	1.30E-03	3.53E-04	3.43E-04	6.66E-04
Octa-CDD	3.01E-03	1.55E-03	8.91E-04	1.82E-03
Total PCDD	4.96E-03	2.12E-03	1.23E-03	2.77E-03
FURANS				
2378 TCDF	ND(3.26E-05)	ND(1.41E-04)	ND(6.85E-05)	.00E+00
Other TCDF	1.38E-03	2.12E-04	1.37E-04	5.77E-04
Penta-CDF	6.51E-04	ND(1.62E-04)	ND(8.91E-05)	2.17E-04
Hexa-CDF	5.70E-04	2.12E-04	ND(3.49E-04)	2.60E-04
Hepta-CDF	8.14E-04	7.06E-04	2.06E-04	5.75E-04
Octa-CDF	3.26E-04	1.06E-03	6.85E-05	4.84E-04
Total PCDF	3.74E-03	2.19E-03	4.11E-04	2.11E-03

ND = not detected (detection limit in parentheses).
ug = 1.0E-06g
8760 operating hours per year

NOTE: Emission factors were calculated using the black liquor dry solids feed rate.

were 0.003 ug total PCDD emitted per Kg feed and 0.002 ug total PCDF emitted per Kg feed (dry solids feed basis). The outlet emission factors for the individual dioxin and furan homologues varied considerably between test runs.

5.4.3 Reduction of Dioxin/Furan Concentrations Due to the ESP.

The dioxin/furans which condense on particulate in the stack gas are removed from the stack gas along with the particulate matter by the pollution control device. The dioxin/furan removal efficiency of the control device is calculated from the difference of the inlet and outlet concentration of each dioxin/furan homologue divided by the inlet concentration of each homologue. Each concentration value may have an analytical uncertainty of ±50%. An analysis of the uncertainty of the control device efficiency (contained in Appendix F) indicates that with a measured efficiency of greater than 67%, the true removal efficiency is most likely positive. With measured efficiencies between 67% and -200%, a definite conclusion cannot be drawn concerning the true removal efficiency, and below -200%, the true removal efficiency is most likely negative.

The measured ESP removal efficiences for each dioxin/furan homologue at Site BLB-A are summarized in Table 5-16. The PCDD/PCDF removal efficiencies across the ESP were widely scattered for the respective homologues and between runs. Run 03 indicates positive removal efficiency across the ESP while no conclusions can be made from the efficiencies calculated for Runs 01 and 02. The overall data is inconclusive concerning the true removal efficiency for the ESP.

5.4.4 Economizer Ash Results

During the pre-survey site visit a single economizer ash sample was collected. This sample was analyzed for dioxin/furan to determine if it was necessary to sample the economizer ash during the actual site testing. Hexa-CDF and octa-CDD were the only homologues detected in concentrations of 0.01 ng/g (ppb) for each respective homologue. The detection limits for the homologues which were not detected were between 0.01 ng/g (ppb) and 0.02 ng/g (ppb). Due to the minimal concentrations of the dioxin/furan homologues found in this sample, the economizer ash was not sampled during the site testing.

TABLE 5-16. MEASURED ESP REMOVAL EFFICIENCIES AT SITE BLB-A[a]

Homologue	ESP Removal Efficiency, (%) Run 1	Run 2	Run 3
Dioxins			
2378 TCDD	--	--	--
Other TCDD	--	- 165	--
Penta-CDD	--	--	--
Hexa-CDD	-27.0	+ 100	--
Hepta-CDD	- 6.1	+55.8	+85.9
Octa-CDD	+10.7	+39.2	+89.5
Total PCDD	+ 2.9	+43.7	+88.7
Furans			
2378 TCDF	--	--	--
Other TCDF	-35.5	+73.5	+92.1
Penta-CDF	+51.0	+ 100	--
Hexa-CDF	+69.1	+86.7	+ 100
Hepta-CDF	+20.1	-47.0	+98.0
Octa-CDF	- 6.2	- 232	--
Total PCDF	+32.0	+47.3	+93.7

NOTE: dash (-) indicates that the species was not detected at the ESP inlet location.

[a] ESP removal efficiency values were calculated using concentration data corrected to 3% O_2 (Table 5-9 and 5-14).

5.5 BLACK LIQUOR PRECURSOR DATA

As discussed in Section 4.3.2, the strong black liquor was sampled at Site BLB-A. These samples were analyzed for chlorinated benzenes, chlorinated biphenyls, and chlorinated phenols.

Table 5-17 summarizes the results of the precursor analyses. Trace levels of pentachlorophenols were detected for Run 02, but overall the specific precursors analyzed for (i.e., chlorobenzenes, chlorophenols, and chlorinated biphenyls) were not detected. This suggests that either (i) the specific precursors analyzed for were not present in the samples, or (ii) the precursors were not easily detected using the GC/MS procedure.

Table 5-18 presents the results of the strong black liquor and weak black liquor total chloride analyses. The chloride concentration was consistent among the three test runs. The greatest deviation of any run from the overall average was 36 percent for the strong black liquor and 27 percent for the weak black liquor. As seen from Table 5-18, the strong black liquor was roughly 2.5 times as concentrated as the weak black liquor with respect to total chloride content. This increase in chloride content follows from the process since the dirty water from the brown stock washers (i.e., weak black liquor) is sent to an evaporation system for solids concentration prior to being fired in the boiler.

5.6 AUXILIARY PROCESS SAMPLE ANALYSES

In addition to the chloride analysis performed on the black liquor samples, chloride analysis was also performed on white liquor, by-product saltcake, and caustic samples collected at Site BLB-A. The results of the strong and weak black liquor chloride analyses are presented above in Section 5.5. Table 5-19 summarizes the data obtained from the total chloride analyses of the other process samples mentioned above. The majority of the chlorine entering the black liquor circuit comes from the caustic and the by-product salt cake with each contributing 122 and 7.7 ug chlorine/Mg of solids burned, respectively.

During the pre-survey plant visit a grab sample of the economizer ash was taken for dioxin/furan analysis. All of the homologues were below the detection limit for the method except for the octa-CDD and hexa-CDF

TABLE 5-17. SUMMARY OF DIOXIN PRECURSOR DATA FOR SITE BLB-A FEED SAMPLES

	Precursor Concentration, ug/g (ppm)			
	Black Liquor Feed			
Precursor Categories	Run 01	Run 02	Run 03	Average
Total Chlorinated Benzenes	ND	ND	ND	--
Total Chlorinated Biphenyls	ND	ND	ND	--
Total Chlorinated Phenols	ND	trace	ND	--

ND = not detected.

TABLE 5-18. TOTAL CHLORIDE ANALYSES OF THE BLACK LIQUOR SAMPLES FOR SITE BLB-A

Liquor	Run No.	Total Chloride Concentration (ug/g)
Strong Black Liquor	01	578
	02	951
	03	1159
	Average	896
Weak Black Liquor	01	320
	02	506
	03	369
	Average	398

TABLE 5-19. TOTAL CHLORIDE ANALYSES OF AUXILIARY LIQUOR CIRCUIT SAMPLES AT SITE BLB-A ($\mu g/g$ as Cl^-)

Test Run	Caustic	By-Product Salt Cake	White Liquor
01	2900	1300	1600
02	600	120	1300
03	320	NS	1700
Average	1300	700	1500

NS = Not sampled. By-product salt cake was not being produced during Run 03.

homologues. Ten parts per trillion of each of these homologues were detected in the economizer ash sample. The detection limits for the ash analysis ranged from 5 to 20 parts per trillion. The doixin/furan contamination in the economizer ash was obviously minimal.

5.7 HCl TRAIN CHLORIDE EMISSIONS DATA

Table 5-20 summarizes HCl train chloride emissions data measured at the electrostatic precipitator outlet sampling location. The data are reported as "front-half," "back-half," and "train-total" chloride emissions. The front-half emissions represent chlorides captured in the probe rinse/filter fraction of the HCl train, which may include metal chlorides contained in the particulate matter. The back-half emissions represent chlorides captured in the HCl sample train impingers, which would include HCl and any metal chlorides that pass through the sample train filter. The train-total emissions represent the sum of the front-half and back-half emissions.

As shown in Table 5-20, the average as-measured train-total chloride emissions concentration was approximately 98 mg/dscm (1.5 grains/dscf). Corrected to 3% O_2 using the Radian CEM data, this corresponds to approximately 110 mg/dscm @ 3% O_2 (1.7 gr/dscf @ 3% O_2). The average train total chloride mass emission rate from the ESP outlet exhaust stack was about 22 Kg/hr (0.97 lb/hr). Chloride emissions were predominantly captured in the back half of the HCl sample train.

TABLE 5-20. HCl TRAIN CHLORIDE EMISSIONS DATA FOR SITE BLB-A AT THE ELECTROSTATIC PRECIPITATOR OUTLET

Parameter	Run 01a	Run 01b	Run 02	Run 03	Average
Total Chloride Concentration (mg/dscm, as measured)					
Front Half	1.2	1.2	1.5	1.6	1.4
Back Half	108	91.2	95.3	91.6	96.7
Train Total	109	92.4	96.9	93.2	98.1
Total Chloride Concentration (mg/dscm, corrected to 3% Oxygen)[a]					
Front Half	1.4	1.3	1.7	1.8	1.5
Back Half	122	103	107	103	109
Train Total	124	104	109	105	110
Total Chloride Mass Emission Rate (Kg/hr)					
Front Half	0.3	0.3	0.3	0.4	0.3
Back Half	24.7	20.4	20.6	20.2	21.5
Train Total	25	20.7	20.9	20.5	21.8

[a] Concentration corrected to 3% O_2 using the equation:

$[Cl^-]$ @ 3% O_2 = $[Cl^-]$, as measured x (20.9 - 3)/(20.9 - %O_2)

where: %O_2 = oxygen concentration in stack gas as measured by EPA Method 3 (See Table 5-5).

6.0 SAMPLING LOCATIONS AND PROCEDURES

Samples were collected from eight different locations at the test site. Two of the locations were for gaseous sampling, four were for liquid sampling, and two were for solid sampling. The source sampling and analysis matrix in Table 4-1 lists the sample locations, measured parameters, sampling methods, and analytical methods that were used.

Details on the sampling locations and methods are discussed in Section 6.1 through 6.3. Analytical procedures for continuous monitoring of CO, CO_2, O_2, NO_x, SO_2, and THC are included in Section 6.1. All other analytical procedures are discussed in Section 7.

6.1 GASEOUS SAMPLING

Four types of gaseous samples were taken during this test program: Modified Method 5 (MM5), HCl, EPA Method 3, and continuous monitoring (CEM). The sampling locations and methods are further discussed in this section.

6.1.1. Gaseous Sampling Locations

6.1.1.1 Electrostatic Precipitator Outlet Exhaust Stack.

The electrostatic precipitator (ESP) outlet exhaust stack sampling location is shown as point C in Figure 4-1. This location was used for dioxin sampling and HCl sampling using MM5 procedures described in Section 6.1.2.1 and 6.1.2.2. Gas velocity, molecular weight, and moisture were determined using EPA Methods 1 through 4. In addition, total reduced sulfur (TRS), CO, O_2, and opacity monitoring were performed by the plant at this location during the test periods.

Dimensions of the ESP outlet exhaust stack sampling location are shown in Figure 6-1. The diameter of the circular stack is 10.5 feet. Sampling ports were located approximately 4 duct diameters downstream of the connection between the ESP outlet ducting and the stack, and approximately 7.2 duct diameters upstream of the top of the stack. Based on EPA Method 1, a total of 24 traverse points were required for velocity determination at this location.

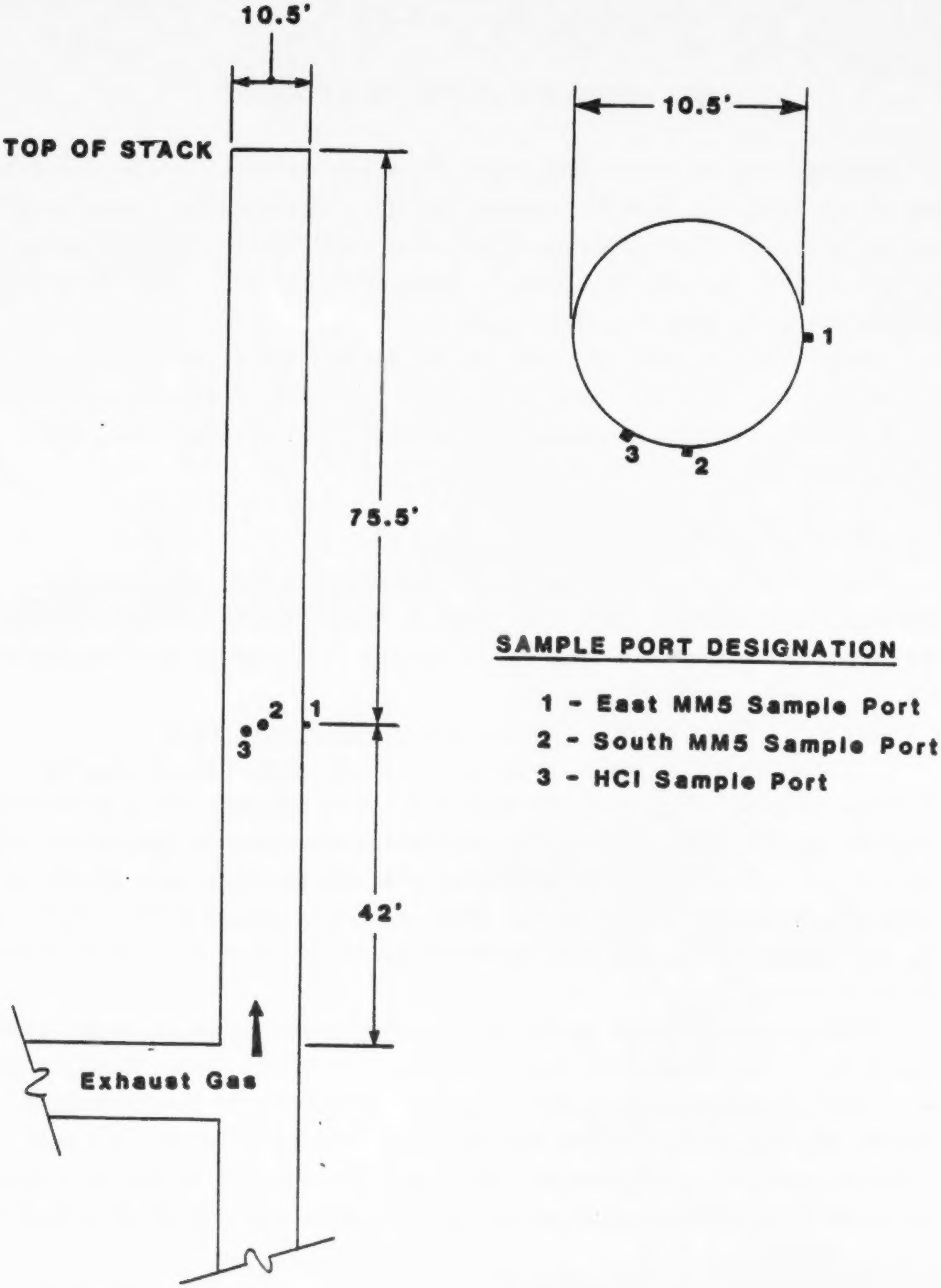

10.5'
TOP OF STACK
10.5'
1
3
2
75.5'
3
2
1
42'
Exhaust Gas
SAMPLE PORT DESIGNATION
1 - East MM5 Sample Port
2 - South MM5 Sample Port
3 - HCl Sample Port

Figure 6-1 Dimensions of Electrostatic Precipitator Outlet Exhaust Stack

6.1.1.2 Black Liquor Boiler Outlet.

The black liquor boiler outlet sampling location (electrostatic precipitator inlet) is shown as point B in Figure 4-1. It consists of two identical rectangular ductwork sections that direct approximately equal volumetric flowrates of boiler exhaust gases to the East and West chambers of the ESP. Each of the two rectangular ductwork sections has four sampling ports. A schematic diagram of the ductwork is shown in Figure 6-2. This location was used for dioxin/furan sampling using MM5 procedures and for continuous monitoring of CO, CO_2, O_2, total hydrocarbons (THC), NO_x, and SO_2. Gas velocity, molecular weight, and moisture were determined using EPA Methods 1 through 4. The dimensions of the black liquor boiler outlet sampling locations relative to the nearest flow disturbances are shown in Figure 6-3. The sampling ports were located less than 1 duct diameter downstream of a 45^0 bend and less than 1 duct diameter upstream of the inlet to the ESP. Seven of the ports were used for MM5 sampling, and the eighth port was dedicated to the continuous monitoring probe. Based on EPA Method 1, a total of 49 traverse points were used for velocity determination at this location.

6.1.2 Gaseous Sampling Procedures

Gaseous sampling procedures used during the testing are listed in Table 6-1. These procedures are discussed in detail in the Tier 4 Quality Assurance Project Plan (QAPP). A brief description of each method and any necessary deviations from the procedures outlined in the QAPP are provided in the following section.

6.1.2.1 Modified Method 5 (MM5).

Gas sampling for dioxins and furans was conducted according to the October 1984 draft of the ASME chlorinated organic compound sampling protocol. Minor deviations from the ASME protocol are discussed later in this section. This sampling method is a modified version of EPA Method 5 that includes a solid sorbent module for trapping vapor phase organics. The only differences in the sampling protocol which were not discussed in the Tier 4 QAPP are:

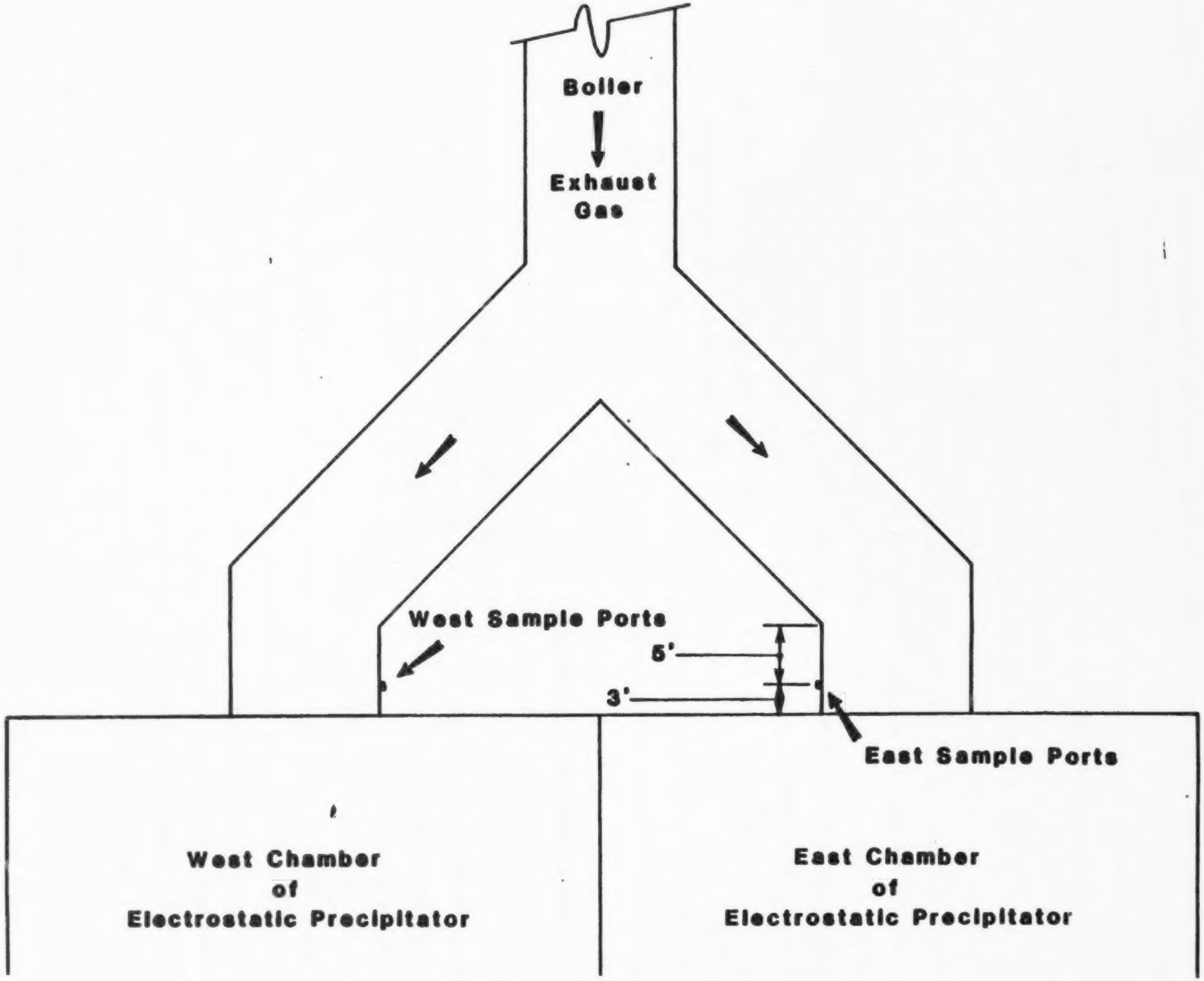

Boiler
Exhaust Gas
West Sample Ports
5'
3'
East Sample Ports
West Chamber of Electrostatic Precipitator
East Chamber of Electrostatic Precipitator

Figure 6-2 Schematic Diagram of Black Liquor Boiler Outlet Ductwork

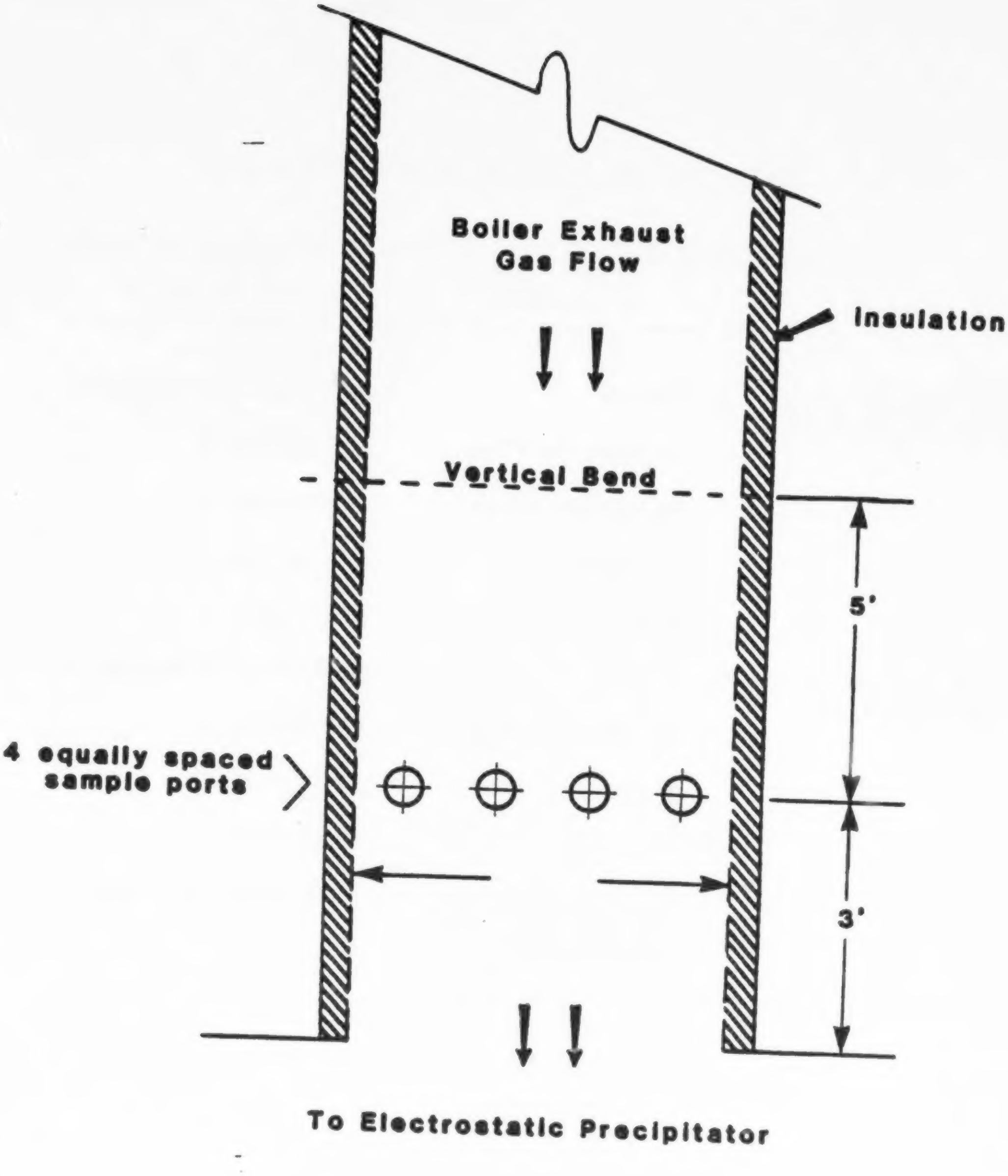

Boiler Exhaust Gas Flow
Insulation
Vertical Bend
5'
4 equally spaced sample ports
3'
To Electrostatic Precipitator

Figure 6-3 Dimensions of Black Liquor Boiler Outlet Sampling Location

TABLE 6-1. SUMMARY OF GAS SAMPLING METHODS FOR SITE 04

Sample Location	Sample Type or Parameter	Sample Collection Method
ESP outlet exhaust stack (Point C on Figure 4-1)	Dioxin	Modified EPA Method 5
	Volumetric Flow	EPA Method 2
	Molecular Weight	EPA Method 3
	Moisture	EPA Method 4
	HCl	HCl train
Black liquor boiler outlet (Point B on Figure 4-1)	Dioxin	Modified EPA Method 5
	Volumetric flow	EPA Method 2
	Molecular weight	EPA Method 3
	Moisture	EPA Method 4
	CO, CO_2, O_2, SO_2 NO_x and THC monitoring	Continuous monitors

(1) Benzene was substituted for hexane or toluene as both the cleanup and extractant solvent for both the MM5 filters and the XAD-2 resin. This was caused by a discrepancy between the draft ASME sampling protocol and the draft ASME analytical protocol. (November 16, 1985)

(2) Methylene chloride was substituted for hexane as the final field rinse solvent for the MM5 train. Methylene chloride was also substituted for hexane in the glassware cleaning procedure. This was caused by a high field blank train. (February 27, 1985)

The MM5 sampling train was used to collect samples at the ESP outlet exhaust stack and at the black liquor boiler outlet sampling location. Following sample recovery, the various parts of the sample (filter, solvent rinses, sorbent trap, etc.) were sent to the EPA's Troika laboratories to quantify 2378-TCDD, tetra- through octa-dioxin homologues, and tetra- through octa-furan homologues. A total of three MM5 test runs were conducted simultaneously at each of the two sampling locations, with one test run being conducted at each location per test day. The MM5 samples were collected isokinetically over a 240-minute on line sampling period at the ESP outlet with a sample flow rate of approximately 0.75 scfm. Sampling was performed during the same time period at the ESP inlet location, but the actual on line sampling period was approximately 140 minutes. Multiple filter changes were required at this location because of the high particulate loading and the "sticky" nature of the particulate. The sample flow rate at the ESP inlet was approximately 0.6 scfm.

A schematic diagram of the MM5 sampling train is shown in Figure 6-4. Flue gas is pulled from the stack through a nozzle and a heated glass probe. Particulate matter is removed from the gas stream by means of a glass fiber filter housed in a teflon-sealed glass filter holder maintained at 248 ± 25°F. The gas passes through a sorbent trap similar to that illustrated in Figure 6-5 for removal of organic constituents. The trap consists of separate sections for (1) cooling the gas stream, and (2) adsorbing the organic compounds on Amberlite XAD-2^R resin (XAD). A chilled impinger train following the sorbent trap is used to remove water from the flue gas, and a dry gas meter is used to measure the sample gas flow.

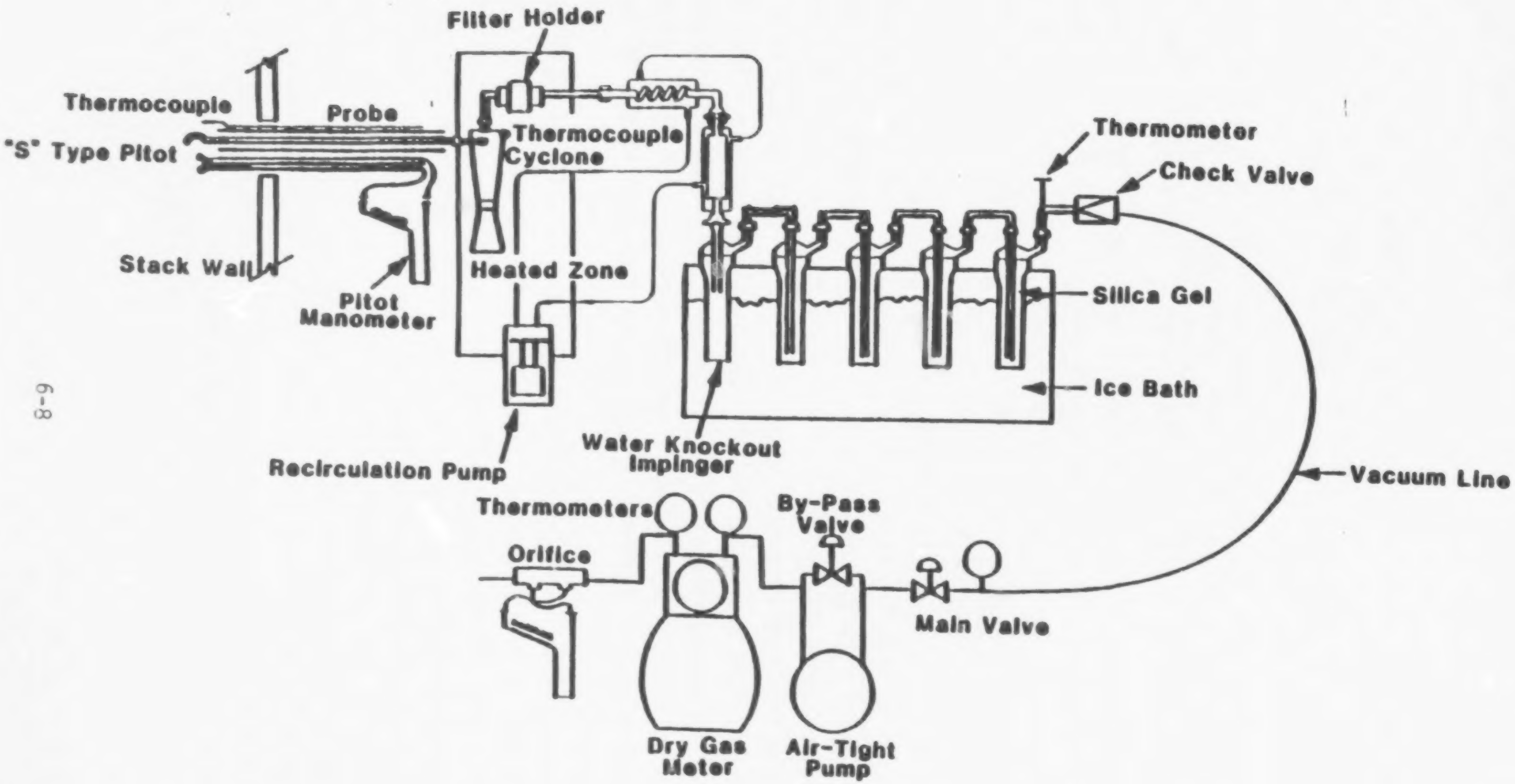

Filter Holder
Thermocouple
Probe
"S" Type Pitot
Thermocouple
Cyclone
Stack Wall
Pitot
Manometer
Heated Zone
Recirculation Pump
Water Knockout
Impinger
Thermometer
Check Valve
Silica Gel
Ice Bath
Vacuum Line
Thermometers
Orifice
By-Pass
Valve
Main Valve
Dry Gas
Meter
Air-Tight
Pump

Figure 6-4 Modified Method 5 Train.

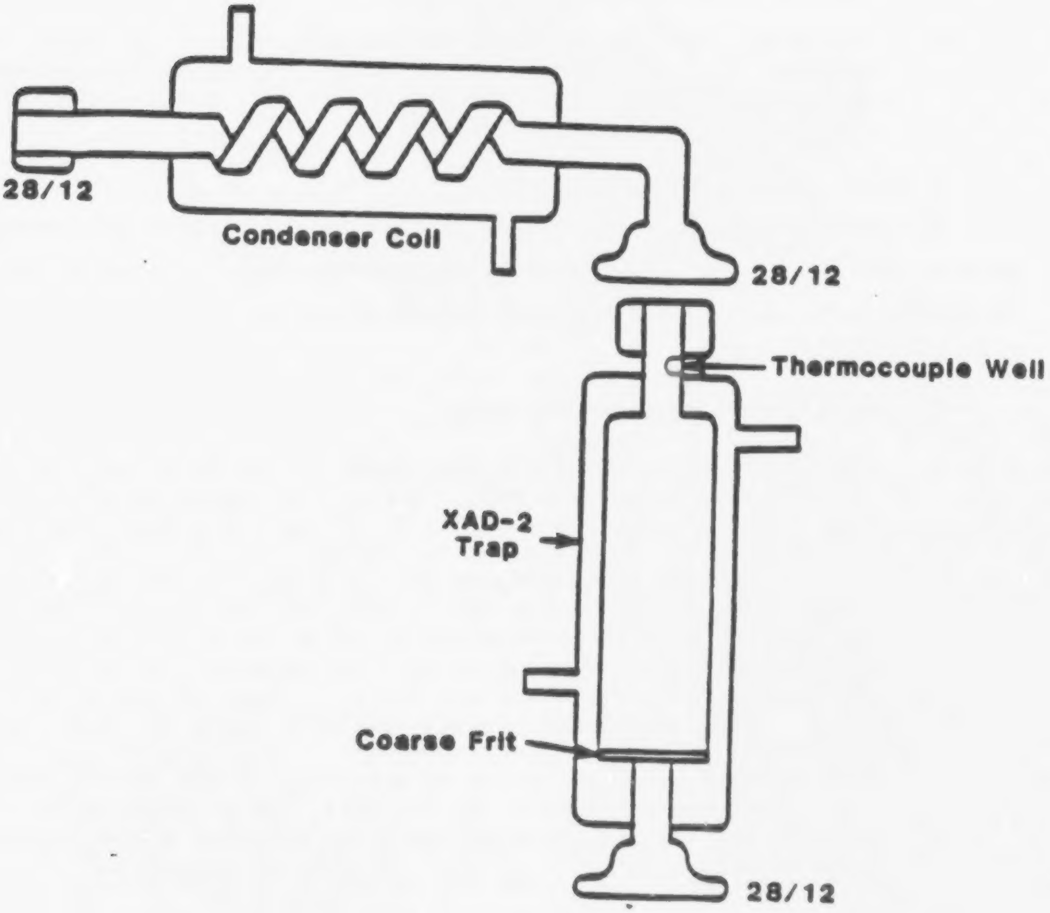

28/12
Condenser Coil
28/12
Thermocouple Well
XAD-2
Trap
Coarse Frit
28/12

Figure 6-5 Adsorbent Sampling System.

Modifications to the ASME protocol that were instituted for this test site include the following:

1. Sample recovery was modified to include water in the sample train rinsing scheme. Water, acetone, and hexane were used in series to recover the probe, back-half/coil, and first impinger samples. Previous black liquor sampling experience has shown that water is necessary because the black liquor boiler particulate is soluble in water but insoluble in acetone.

2. The probe brush is specified in the ASME protocol as being inert material with a stainless steel handle. To ensure cleanliness, a separate nylon bristle brush attachable to a stainless steel handle was used for each probe cleaning.

6.1.2.2 HCl Determination.

HCl concentrations in the ESP outlet exhaust stack were determined using another modification of EPA Method 5. The sample train components and operation were identical to those of Method 5 with the following exceptions:

1. No knockout impinger was used.

2. During the first HCl train run, water in the first two impingers was replaced with 0.1 m NaOH. During the remaining HCl train (HCl runs 2 through 4), water in the first two impingers was replaced with 0.1M KOH. As discussed in Section 4.1 , the substitution of KOH for NaOH in the impingers was performed at the suggestion of NCASI. The intent of the substitution was to eliminate NaCl interferences in the determination of HCl emissions by utilizing sodium, sulfate, and chloride material balances on the impinger solutions. Upon further study of this issue, it was determined that several additional chemical analysis would be needed to remove the potential NaCl interference. The uncertainty of the final result would be increased according to the uncertainty of each additional analysis. As a result, the plan to remove NaCl interferences was dropped and only the chloride analysis results were reported.

3. Sampling was single point isokinetic with the nozzle placed at points in the stack with approximate average velocity.

4. The moisture/NaOH or KOH in the impingers was saved for laboratory analysis by ion chromatography for total chlorides. The impinger catch was analyzed by Radian's Austin, Texas laboratory.

Recovery of the HCl train provided a sample consisting of three components: probe rinse, filter, and back-half rinse/impinger catch.

A total of four HCl train runs were performed at the ESP outlet stack sampling location. HCl train runs 1 and 2 were performed on sample days 1 and 2, while HCl train runs 3 and 4 were performed on sample day 3. The fourth HCl run was performed because a broken impinger may have invalidated data from the first HCl run. The HCl samples were collected over on-line sample times of 100 to 175 minutes at a sample flow rate of approximately 0.8 scfm.

6.1.2.3 Volumetric Gas Flow Rate Determination.

The volumetric gas flow rate was determined at the ESP inlet and outlet sampling locations using EPA Method 2. Based on this method, the volumetric gas flow rate was determined by measuring the average velocity of the flue gas and the cross-sectional area of the duct. The average flue gas velocity was calculated from the average gas velocity pressure (P) across a S-type pitot tube, the average flue gas temperature, the wet molecular weight, and the absolute static pressure.

6.1.2.4 Flue Gas Moisture Determination.

The moisture content of the flue gas was determined at the ESP inlet and outlet sampling locations using EPA Method 4. Based on this method, a measured volume of particulate-free gas was pulled through a chilled impinger train. The quantity of condensed water was determined gravimetrically and then related to the volume of gas sampled to determine the moisture content.

6.1.2.5 Flue Gas Molecular Weight Determination.

The integrated sampling technique described in EPA Method 3 was used at the ESP inlet and outlet sampling locations to obtain a composite flue gas sample for fixed gas (O_2, CO_2, N_2) analysis. The fixed gas analysis was used to determine the molecular weight of the gas stream. A small diaphram pump and a stainless steel probe were used to extract single point flue gas samples. The samples were collected in a Tedlar^R bag. Moisture was removed from the gas sample by a water-cooled condenser so that the fixed gas analysis is on a dry basis.

The composition of the gas sample was determined using a Shimadzu Model 3BT analyzer instead of the Fyrite or Orsat analyzer prescribed in EPA Method 3. The Shimadzu instrument employs a gas chromatograph and a thermal conductivity detector to determine the fixed gas composition of the sample.

6.1.2.6 Continuous Monitors.

Continuous monitoring was performed at the boiler outlet sampling location for O_2, CO_2, CO, NO_x, SO_2, and THC throughout the 4 to 6-hour period that MM5 dioxin sampling was being conducted each test day. The primary objectives of the continuous monitoring effort were to observe fluctuations in flue gas parameters and to provide an indication of combustion conditions. Sample acquisition was accomplished using an in-stack filter probe and a 150 ft length of heat-traced Teflon^R sample line connected to a mobile laboratory. The heat-traced sample line was maintained at a temperature of at least 120°C to prevent condensation in the sample line. The stack gas sample was drawn through the in-stack filter and sample line using pumps located in the mobile laboratory. Sample gas to be analyzed for CO, CO_2, O_2, SO_2, and NO_x was pumped through a sample gas conditioner, which consisted of an ice bath and knockout trap. The sample gas conditioner removes moisture and thus provides a dry gas stream for analysis. A separate unconditioned gas stream was supplied to the THC analyzer for analysis on a wet basis.

An Anarad Model 412 nondispersive infrared (NDIR) analyzer was use to measure CO and CO_2; a Beckman Model 755 paramagnetic analyzer was used to measure O_2; a Teco Model 10 chemiluminescent analyzer was used to measure NO_x; a Teco Model 40 pulsed fluorescence analyzer was used to measure SO_2; and a Beckman Model 402 flame ionization analyzer was used to measure THC.

6.2 LIQUID SAMPLING

Four types of liquid samples were obtained during this test program: strong black liquor, caustic (sodium hydroxide), white liquor, and weak black liquor. The corresponding sampling locations are shown on Figure 4-1 as A, D, E, F, and G, respectively.

6.2.1 Strong Black Liquor Sampling

Strong black liquor samples were taken from the mix tank where liquid sulfur is added to the concentrated black liquor from the evaporators. Black liquor from the mix tank is fed directly to the feed guns in the boiler. The host site performs daily strong black liquor sampling at this location using a dipper-type sampler.

Three identical composite strong black liquor samples were obtained during each of the three tests: a 1-liter composite was shipped to Troika for dioxin analysis, another 1-liter composite was returned to Radian/RTP for dioxin precursor analysis, and a 125 ml composite was sent to Radian/Austin for total chlorine analysis. The composite strong black liquor samples for each run were comprised of hourly grab samples from the mix tank. It was necessary to heat the running hourly sample composite to prevent the sample from solidifying prior to taking the final sample aliquots. This was accomplished by wrapping the sample composite bottle with rubber-coated heat tape.

6.2.2 Auxiliary Black Liquor Circuit Sampling

Samples of caustic, white liquor, and weak black liquor were obtained to indicate the relative amounts of chlorine entering the black liquor circuit through various input sources. One 125 ml composite sample of each stream was obtained during each test. Individual samples were taken twice during each test run, and the composite sample were prepared accordingly. The samples were analyzed for total chlorine content only. The chlorine-content data was used in conjunction with mass flow data to determine the relative amounts of chlorine associated with each potential source of chlorine input to the black liquor circuit. The chlorine analysis was performed by the Radian Analytical Services laboratory in Austin, Texas using ion chromatography.

Caustic samples were taken from a sample tap in the transfer line leading from caustic storage to the causticizing area in the pulping circuit. White liquor samples were taken from a sample tap on the white liquor storage tank because there was no sampling location available on the transfer line leading from the storage tank to the digesters. Weak black liquor samples were taken from a sample tap in the transfer line leading to the concentrators.

6.3 SOLID SAMPLING

Two types of solid samples were obtained at Site BLB-A: by-product salt cake from the ClO_2 generation process and soils from plant property. The sampling locations and methods are discussed below.

6.3.1 By-product Salt Cake Sampling

Samples of by-product salt cake from the ClO_2 generation system were obtained during Runs 01 and 02 at Site 04. This material was not being produced or fed to the black liquor circuit during Run 03, so no samples could be taken then. During Runs 01 and 02, approximately 300 grams of wet salt cake were obtained twice during the test run from a rotary filter used to separate precipitated salt cake from an aqueous by-product stream of the ClO_2 generation system. At the end of the test run a 125 g sample of the run composite was placed in a 125 ml bottle and sent to Radian's Austin Texas laboratory for total chloride analysis.

6.3.2 Soil Sampling

A single composite soil sample comprised of 10 individual soil samples was obtained at Site BLB-A. Soil sampling protocol for Tiers 3, 5, 6, and 7 of the National Dioxin Study are specified in the document, "Sampling Guidance Manual for the National Dioxin Study." A similar protocol was used for soil sampling at this test site. A total of 10 soil sampling locations were selected on plant property surrounding the black liquor boiler/power complex. The 10 individual soil sampling locations are shown in Figure 6-6 and are listed in Table 6-2. Soil samples were collected by forcing a bulb planter into the soil to a depth of 3 inches. The soil samples were then composited in a clean stainless steel bucket. Five hundred grams of the composite was placed in a 950 ml glass amber bottle and returned to Radian/RTP for archiving.

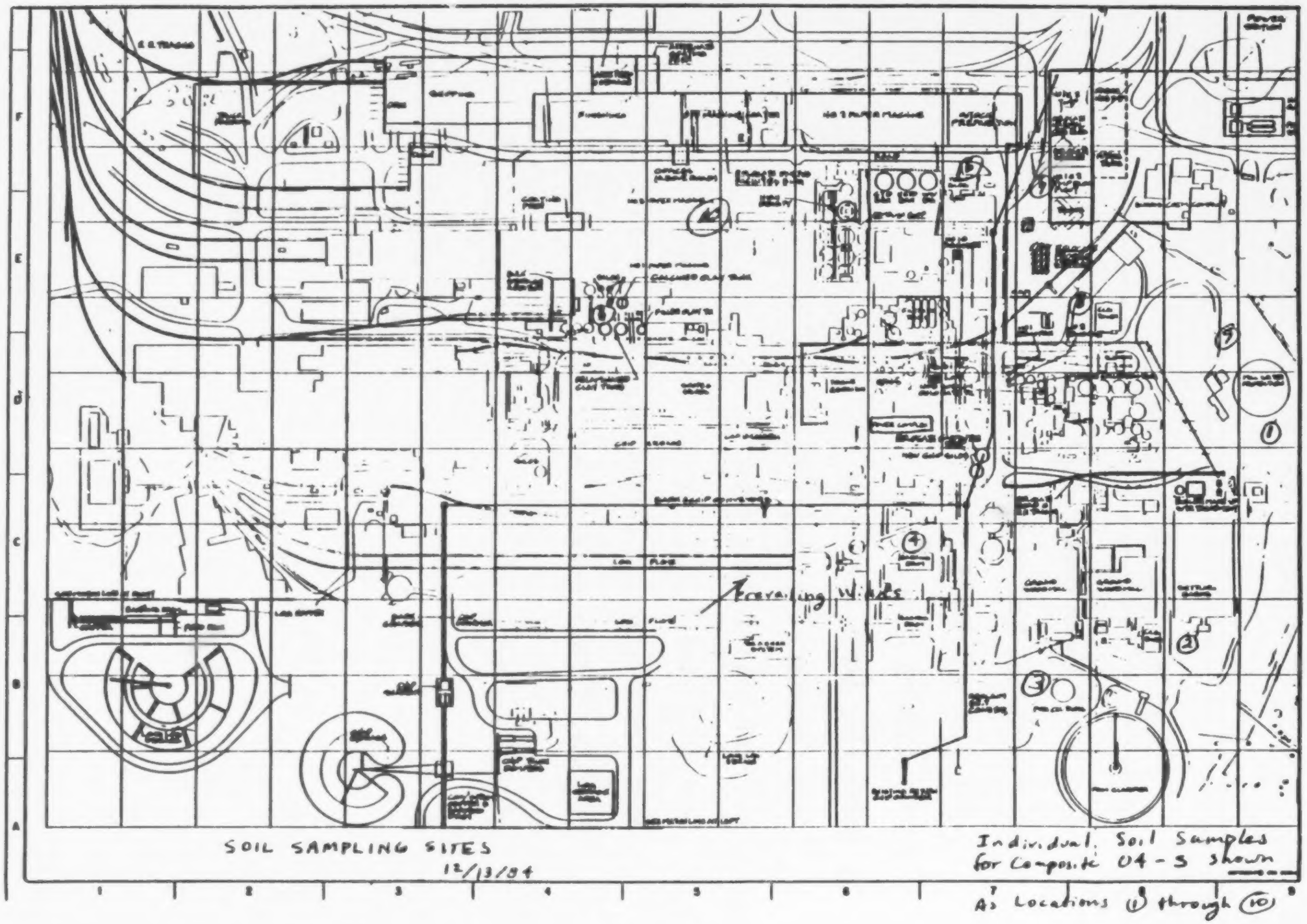

SOIL SAMPLING SITES
12/13/94
Individual Soil Samples
for Composite 04-5 shown
As Locations ① through ⑩
Prevailing Winds
A
B
C
D
E
F
1
2
3
4
5
6
7
8

Figure 6-6 Soil Sampling Locations at Site BLB-A

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TABLE 6-2. DESCRIPTION OF SOIL SAMPLING LOCATIONS AT SITE BLB-A

Individual Sample	Sampling Location Description[a]
1	Near "mill water protection" area (D9)
2	Near settling basins (B8)
3	Near fuel oil tanks (B7)
4	Near barking drum (C6)
5	Near clay tanks (E4)
6	Near technical building (F7)
7	Near TMP bleach plant (F7)
8	Near "CLG Tower" (E7)
9	Near "Mill water protection" area (D8)
10	Near No. 3 paper machine (E5)

[a] Sampling location coordinates for Figure 6-5 are listed in parenthesis.

7.0 ANALYTICAL PROCEDURES

Laboratory procedures used to quantify dioxins/furans and dioxin/furan precursors in the Tier 4 samples are described in this section. Analyses for dioxins/furans were performed by EPA's ECL-BSL and EMSL-RTP laboratories. The procedures used for these analyses are described in detail in the Analytical Procedures and QA Plan for the Analysis of Tetra through Octa CDD's and CDF's in Samples from Tier 4 Combustion and Incineration Processes (addendum to EPA/600/3-85-/019, April, 1985).

Black liquor boiler feed samples from Site BLB-A were analyzed to determine concentrations of chlorinated phenols (CP), chlorobenzenes (CB), polychlorinated biphenyls (PCB's), total organic halogen (TOX), and total chlorine. Procedures used for these analyses are detailed in Section 7.2.

7.1 DIOXINS/FURANS

The analytical procedures described in this section were used for the determination of PCDD and PCDF in stack effluent samples (MM5). Samples consisting of organic solvents, aqueous solutions and solids were prepared for analysis using slightly different procedures. The organic solvent samples consisted of rinses from the MM5 probe, nozzle, filter housing and condenser coil. The impinger catch was an aqueous solution and the solid samples included the filter and XAD^R resin. All aqueous and solid samples were extracted within 14 days of collection and then stored in this form until analysis. Isotopically-labeled surrogate compounds were added to all samples prior to extraction to allow determination of method efficiency and for quantification purposes.

Organic liquid samples (acetone and hexane or methylene chloride) were concentrated using a nitrogen blowdown apparatus. The residue, which contained particulates from the train probe and nozzle, was combined with the filter and handled as a solid sample. Solid samples were extracted with benzene in a Soxhlet apparatus for a period of at least 16 hours. The sample was then concentrated by nitrogen blowdown and subjected to chromatographic cleanup procedures.

Aqueous solutions were extracted with hexane by vigorous shaking for a three hour period. This extraction procedure was repeated three times, with the organic fractions ultimately being combined and concentrated for chromatographic cleanup.

The cleanup procedure involved using liquid chromatographic columns to separate the compounds of interest from other compounds present in the samples. Four different types of columns were used: a combination acid and base modified silica gel column, a basic alumina column, a PX-21 carbon/celite 545 column and a silica/diol micro column. These were used in successive steps, with the last two being used only if necessary.

The cleaned samples were analyzed using high resolution gas chromatography/high resolution mass spectrometry (GC/MS). The conditions for the analyses were as follows:

Gas Chromatograph - Injector configured for capillary column, splitless injection, injector temperature 280°C, helium carrier gas at 1.2 ml/min, initial column temperature 100°C: final column temperature 240°C, interface temperature 270°C.

Mass Spectrometer - Varian/MAT Model 311A, electron energy 70ev, filament emission 1MA, mass resolution 8,000 to 10,000, ion source temperature 270°C.

7.2 DIOXIN/FURAN PRECURSORS

Feed samples for Site BLB-A were analyzed by Radian/RTP for chlorophenols (CP), chlorobenzenes (CB) and polychlorinated biphenyls (PCB's) by GC/MS, total organic halides (TOX) by GC/Hall detector, and total chlorine by Parr Bomb combustion followed by ion chromatography. Analytical procedures are discussed in the following sections.

7.2.1 GC/MS Analyses

The analytical procedures used for determining CP, CB, and PCB concentrations in feed samples are modified versions of procedures typically used for the analysis of MM5 train components.

7.2.1.1 Sample Preparation

A flow chart for the sample preparation procedure used for Site BLB-B feed samples is shown in Figure 7-1. The first step involved adding 200 mL of

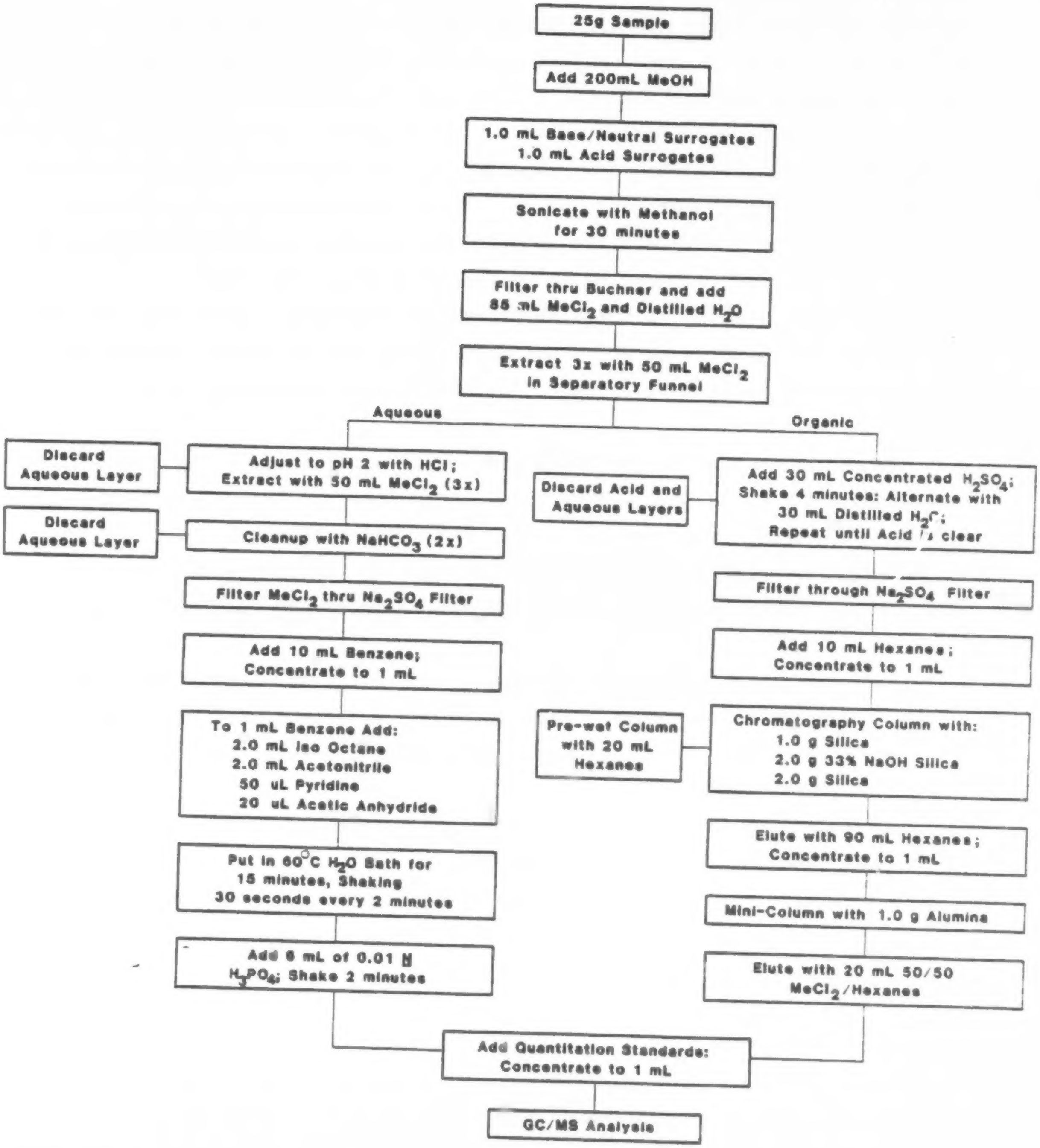
25g Sample
Add 200mL MeOH
1.0 mL Base/Neutral Surrogates
1.0 mL Acid Surrogates
Sonicate with Methanol for 30 minutes
Filter thru Buchner and add 85 mL $MeCl_2$ and Distilled H_2O
Extract 3x with 50 mL $MeCl_2$ in Separatory Funnel
Aqueous
Organic
Discard Aqueous Layer
Adjust to pH 2 with HCl; Extract with 50 mL $MeCl_2$ (3x)
Discard Aqueous Layer
Cleanup with $NaHCO_3$ (2x)
Filter $MeCl_2$ thru Na_2SO_4 Filter
Add 10 mL Benzene; Concentrate to 1 mL
To 1 mL Benzene Add:
2.0 mL Iso Octane
2.0 mL Acetonitrile
50 uL Pyridine
20 uL Acetic Anhydride
Put in 60°C H_2O Bath for 15 minutes, Shaking 30 seconds every 2 minutes
Add 6 mL of 0.01 N H_3PO_4; Shake 2 minutes
Discard Acid and Aqueous Layers
Add 30 mL Concentrated H_2SO_4; Shake 4 minutes: Alternate with 30 mL Distilled H_2O; Repeat until Acid is clear
Filter through Na_2SO_4 Filter
Add 10 mL Hexanes; Concentrate to 1 mL
Pre-wet Column with 20 mL Hexanes
Chromatography Column with:
1.0 g Silica
2.0 g 33% NaOH Silica
2.0 g Silica
Elute with 90 mL Hexanes; Concentrate to 1 mL
Mini-Column with 1.0 g Alumina
Elute with 20 mL 50/50 $MeCl_2$/Hexanes
Add Quantitation Standards: Concentrate to 1 mL
GC/MS Analysis

Figure 7-1. Sample preparation flow diagram for Site BLB-A precursor analyses.

methanol to the sample. The next step in the procedure involved adding labeled surrogate compounds to provide a measure of extraction method efficiency. The next step involved sonicating the sample for 30 minutes. The sonicated sample was filtered and rinsed with 85 mL methylene chloride ($MeCl_2$) and distilled H_2O. The filtrate was extracted three times with 50 mL $MeCl_2$ in a separatory funnel and the resulting aqueous and organic fractions saved for derivatization and/or further cleanup. These procedures involve initial extraction of the sample with an appropriate solvent, preliminary separation of the compounds of interest by solvent partitioning and liquid chromatography, and analysis of the processed fractions. Solutions containing CB and PCB are injected directly into the GC/MS, and solutions containing CP are derivatized prior to injection. Details on the procedures used for Site 05 samples are provided in the sections below.

The aqueous fraction (or acids portion) was acidified to pH 2 with HCl and then extracted three times with $MeCl_2$, followed by two extractions with $NaHCO_3$. The $MeCl_2$ from this extraction was dried with anhydrous Na_2SO_4, exchanged to benzene, and concentrated using a nitrogen blowdown apparatus. Acetylation of any CP present in the sample involved the following steps:

1. Add 2.0 mL isooctane, 2.0 mL acetonitrile, 50 uL pyridine, and 20 uL acetic anhydride to the extract. Put the test tube containing the extract in a 60°C water bath for 15 minutes, shaking 30 seconds every 2 minutes.
2. Add 6 mL of 0.01 N H_3PO_4 to the test tube and agitate the sample for 2 minutes on a wrist action shaker.
3. Remove the organic layer and add the quantitation standard. Concentrate the sample in a Reacti-Vial at room temperature (using prepurified N_2) to 1 mL prior to GC/MS analysis.

Cleanup of the organic (or base/neutrals) layer from the initial $MeCl_2$ extraction involved successively washing the extract with concentrated H_2SO_4 and deionized water. The acid or water was added in a 30 mL portion and the sample was shaken for two minutes. After the aqueous and organic layers were completely separated, the aqueous or acid layer was discarded. The acid washing procedure was repeated until the acid layer was colorless. The sample was then dried with anhydrous Na_2SO_4, exchanged into hexanes and concentrated. Final cleanup of the sample by column chromatography involved the following procedure.

A glass macro-column, 20 mm o.d. x 230 mm in length, taper to 6 mm o.d. on one end was prepared. The column was packed with a plug of silanized glass wool, followed successively by 1.0 g silica, 2.0 g silica containing 33% (w/w) 1 M NaOH, and 2.0 g silica. The concentrate was quantitatively transferred to the column and eluted with 90 mL hexanes. The entire eluate was collected and concentrated to a volume of 1 mL in a centrifuge tube, as above.

A disposable liquid chromatography mini-column was constructed by cutting off a 5-mL Pyrex disposable pipette at the 2.0 mL mark and packing the lower portion of the tube with a small plug of siliconized glass wool, followed by 1 g of Woehlm basic alumina, which has been previously activated for at least 16 hours at 600°C in a muffle furnace and cooled in a desiccator for 30 minutes just before use. The concentrated eluate from above was quantitatively transferred onto the liquid chromatography column, and the centrifuge tube was rinsed consecutively with two 0.3-mL portions of a 3 percent $MeCl_2$:hexanes solution, and the rinses were transferred to the chromatography column.

The column was eluted with 20 mL of a 50 percent (v/v) $MeCl_2$:hexanes, and the elute was retained. The retained fraction was concentrated to a volume of approximately 1.0 mL by heating the tubes in a water bath while passing a stream of prepurified N_2 over the solutions. The quantitation standard was added and the final volume was adjusted to 1.0 mL prior to GC/MS analysis.

7.2.1.2 Analysis

Analyses for CP, CB and PCBs present in the feed sample extracts were performed using a Finnigan Model 5100 mass spectrometer using selected ion monitoring. A fused silica capillary column was used for chromatographic separation of the compounds of interest. Analytical conditions for the GC/MS analysis are shown in Table 7-1.

Tuning of the GC/MS was performed daily as specified in the Tier 4 QA Project Plan. An internal standard calibration procedure was used for sample quantitation. Compounds of interest were calibrated against a fixed concentration of either d_{12}-chrysene (CB, PCB) or d_8-naphthalene (CP).

TABLE 7-1. INSTRUMENT CONDITIONS FOR GC/MS PRECURSOR ANALYSES

Parameter	Chlorobenzenes/ Polychlorinated Biphenyls	Chlorophenols
Column	30 m WB DB-5 (1.0 u film thickness) fused silica capillary	
Injector Temperature	290°C	290°C
Separator Oven Temperature	290°C	290°C
Column Head Pressure	9 psi	9 psi
He flow rate	1 mL/min	1 mL/min
GC program	40(4)-290°C, 10°/min & hold	40(1)-290°C, 12°/min & hold
Emission Current	0.50 ma	0.50 ma
Electron Energy	70 ev	70 ev
Injection Mode	Splitless 0.6 min, then 10:1 split	
Mode	Electron ionization, Selected Ion Monitoring	

Compounds of the calibration solution are shown in Table 7-2. For multi-point calibrations, this solution was injected at levels of 10, 50, 100, and 150 ng/mL.

Compound identification was confirmed by comparison of chromatographic retention times and mass spectra of unknowns with retention times and mass spectra for reference compounds. Since the selected ion monitoring technique was necessary for the types of samples analyzed, care was taken to monitor a sufficiently wide mass region to avoid the potential for reporting false positives.

The instrument detection limit was estimated to be approximately 500 picograms on column. For a 50 g sample and 100 percent recovery of the analyte, this corresponds to a feed sample detection limit of 10 ppb.

7.3 TOTAL CHLORINE ANALYSIS

Total chlorine concentrations in feed samples were determined by Parr Bomb combustion followed by ion chromatography (IC). A 0.5g sample was placed in the Parr Bomb with 10 mL of a 50 g/L Na_2CO_3 solution. After combustion of the samples according to standard procedures (ASTM 2015), the contents of the bomb were rinsed into a 100 mL flask and diluted to 100 mL. The resulting solution was analyzed for chloride concentration (Cl^-) by IC using standard anion conditions. For samples difficult to combust (such as sludges), 25 drops of paraffin oils were added to the bomb prior to combustion.

TABLE 7-2. COMPONENTS OF THE CALIBRATION SOLUTION

Base/Neutrals

4-chlorobiphenyl
3,3'-dichlorobiphenyl
2,4',5-trichlorobiphenyl
3,3'4,4'-tetrachlorobiphenyl
2,2',6,6'-tetrachlorobiphenyl
2,2,4,5,6-pentachlorobiphenyl
2,2',4,4',5,5'-hexachlorobiphenyl
2,2',3,4,4',5',6-heptachlorobiphenyl
2,2',3,3',4,4',5,5'-octachlorobiphenyl
2,2',3,3',4,4',5,6,6'-nonachlorobiphenyl
decachlorobiphenyl
p-dichlorobenzene
1,2,4-trichlorobenzene
1,2,3,5-tetrachlorobenzene
pentachlorobenzene
hexachlorobenzene
d_4-1,4-dichlorobenzene (SS)[1]
3-bromobiphenyl (SS)
2,2',5,5'-tetrabromobiphenyl (SS)
2,2',4,4',6,6'-hexabromobiphenyl (SS)
octachloronaphthalene (QS)[2]
d_{10}-phenanthrene (QS)
d_{12}-chrysene (QS)

Acids

2,5-dichlorophenol
2,3-dichlorophenol
2,6-dichlorophenol
3,5-dichlorophenol
3,4-dichlorophenol
2,3,5-trichlorophenol
2,3,6-trichlorophenol
3,4,5-trichlorophenol
2,4,5-trichlorophenol
2,3,4-trichlorophenol
2,3,5,6-tetrachlorophenol
pentachlorophenol
d_6-phenol (SS)
d_4-2-chlorophenol (SS)
${}^{13}C_6$-pentachlorophenol (SS)
d_8-naphthalene (QS)
2,4,6-tribromophenol (QS)
d_{10}-phenanthrene (QS)
d_{12}chrysene (QS)

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[1] Surrogate standard.

[2] Quantitation standard.

8.0 QUALITY ASSURANCE/ QUALITY CONTROL (QA/QC)

This section summarizes the results of quality assurance and quality control (QA/QC) activities for Site BLB-A. The flue gas and ash dioxin/furan data for this site were generally within the QC specifications presented in the Tier 4 QAPP. All of the surrogate recoveries for labeled TCDDs were within the specified limits of 50 to 120 percent. The surrogate recoveries for the ESP outlet, Run 02 sample was the only run not within the QC limits of 40 to 120 percent for hepta- and octa-CDDs. The results of the analysis of the fortified laboratory QC sample were all within 33 percent of the true value which is well within the Tier 4 objective of ± 50 percent. These data indicate that the dioxin/furan results are within accuracy criteria specified for Tier 4.

The dioxin/furan precursor analysis of the feed samples was not as accurate as the dioxin/furan homologue analysis. Surrogate recoveries of the base neutrals fraction were generally within the specified QC limits of ± 50 percent; however, the surrogate acid fractions were generally below the specified limits. In spite of the low recoveries of the acid fractions, the dioxin/furan precursor results are considered a reasonable approximation of the true precursor concentration in the feed samples.

The following sections summarize the results of all Site BLB-A QA/QC activities. Manual gas sampling methods are considered in Section 8.1 and continuous emission monitoring and molecular weight determinations are considered in Section 8.2. The laboratory analysis QA/QC activities are summarized in Section 8.3.

8.1 MANUAL GAS SAMPLING

Manual gas sampling methods used at Site 04 included Modified Method 5 (MM5), the HCl acid train and EPA Methods 1 through 4. These methods are discussed in Section 6.0. Quality assurance and quality control (QA/QC) activities for the manual methods centered around 1) equipment calibration, 2) glassware precleaning, 3) procedural QC checks and 4) sample custody procedures. Key activities and QC results in each of these areas are discussed in this section. Also discussed are problems encountered that may have affected data quality.

Pretest calibrations or inspections were conducted on pitot tubes, sampling nozzles, temperature sensors and analytical balances. Both pre- and post-test calibrations were also performed on dry gas meters. All of this equipment met the calibration criteria specified in the QAPP. Differences in pre- and post-test dry gas meter calibrations were less than 3.4 percent.

An extensive precleaning procedure was implemented for all sample train glassware and sample containers. This cleaning procedure, which is outlined in Table 8-1, was implemented to minimize the potential for sample contamination with substances that could potentially interfere with the analysis for dioxins and furans. To minimize the potential for contamination in the field, all sample train glassware was kept capped until use and a controlled environment was maintained in the recovery trailer during sample train assembly and recovery.

Procedural QC activities during manual gas sampling focused on:

- inspecting equipment visually
- collecting sampling train blanks
- ensuring the proper location and number of traverse points
- conducting pre-test, port change, and post-test sample train leak checks
- maintaining proper temperatures at the filter housing, sorbent trap and impinger train
- maintaining isokinetic sampling rates, and
- recording all data on preformatted data sheets.

Results of isokinetic calculations for the MM5 test runs are shown in Table 8-2. As shown in Table 8-2, the average isokinetic sampling rate for the MM5 and sampling trains achieved the QA objective of ± 10 percent for all test runs.

Sample custody procedures used during this program emphasized careful documentation of the samples collected and the use of chain-of-custody records for samples to be transported. Steps taken to identify and document samples collected included labeling each sample with a unique alphanumeric

TABLE 8-1. GLASSWARE PRECLEANING PROCEDURE

NOTE: USE DISPOSABLE GLOVES AND ADEQUATE VENTILATION

1. Soak all glassware in hot soapy water (Alconox) 50° C or higher.
2. Distilled/ deionized H_2O rinse (X3)[a]
3. Chromerge rinse if glass, otherwise skip to 6.
4. High purity liquid chromatography grade H_2O rinse (X3).
5. Acetone rinse (X3), (pesticide grade).
6. Hexane rinse (X3), (pesticide grade).
7. Cap glassware with clean glass plugs or hexane rinsed aluminum foil.

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[a] (X3) = three times.

TABLE 8-2. SUMMARY OF ISOKINETICS RESULTS FOR MM5 SAMPLING TRAINS, SITE BLB-A

Run	ESP Outlets Isokinetics	Meets OC Objective?	ESP Inlet Isokinetics	Meets QC Objective?
01	91.7	Yes	92.5	Yes
02	106.5	Yes	98.7	Yes
03	108.8	Yes	104.7	Yes

NOTE: The quality assurance objective for MM5 sampling was isokinetics of 100 ± 10 percent.

code and logging the sample in a master sample logbook. All samples shipped to Troika or returned to Radian were also logged on chain-of-custody records that were signed by the sampler at shipment and then by the receiving laboratory when the samples arrived. Each sample container was also sealed with chain-of-custody seal so that the container could not be opened without tearing the seal.

8.2 CONTINUOUS MONITORING/ MOLECULAR WEIGHT DETERMINATION

Flue gas parameters monitored continuously during the MM5 test runs included CO, CO_2, O_2, total hydrocarbons (THC), SO_2 and NO_x. Concentrations of CO_2, O_2, and N_2 were also determined for integrated bag samples of stack gas. Quality control results for these analyses are discussed in this section.

Drift check and quality control standard analysis results for the continuously monitored flue gas parameters are summarized in Table 8-3. The acceptance criterion for drift checks was an instrument drift within ±10 percent. All data reduction was performed by assuming a linear drift of instrument response over the test day. The largest calibration drifts were observed for CO and CO_2, both of which exceeded acceptance criterion for two of the three test runs. The instrument showing the smallest drift was the O_2 monitor.

The quality control standards for this program consisted of mid-range standards that were not used for instrument calibration but were analyzed immediately after calibration to provide data on day-to-day instrument variability. The acceptance criterion for each control standard was agreement within ±10 percent of the running mean value. All of the instruments met this criterion on each test day except for the CO monitor. However, failure of the CO monitor to meet the acceptance criterion during test runs 2 and 3 is not entirely unexpected. The QC standard (2060 ppmv) was above the calibration range selected for the CO instrument during these test runs (0 to 520 ppmv) and, the CO instrument shows some non-linearity at low concentrations. The instrument was calibrated at a low range to maximize instrument accuracy near the CO levels present in the flue gas.

TABLE 8-3. SUMMARY OF DRIFT CHECK AND CONTROL STANDARD RESULTS

			Drift Check			QC Standard			
Test Date	Test Run	Parameter	Input Concentration	Instrument Drift %^{a}	Meets QC?^{b}	Input Concentration	Output Concentration	Difference From Running Mean, %	Meets QC?^{c}
12/11/84	01	O_2	21.2 %	- 0.77	yes	-	-	-	yes
12/12/84	02	O_2	21.2 %	- 0.38	yes	3.12 %	3.16	- .63	yes
12/13/84	03	O_2	21.2 %	ND^e	ND^e	3.12 %	3.19	.95	yes
12/11/84	01	CO	5430 ppmv	0.12	yes	-	-	-	-
12/12/84	02	CO	5430 ppmv	1.92	yes	520 ppm	728 ppm	+ 16.7 %	no
12/13/84	03	CO	5430 ppmv	e	e	520 ppm	480 ppm	- 16.7 %	no
12/11/84	01	CO_2	17.6 %	6.01	yes	-	-	-	-
12/12/84	02	CO_2	17.6 %	17.9	no	5.2 %	5.66 %	+ 4.2 %	yes
12/13/84	03	CO_2	17.6 %	ND^e	ND^e	5.2 %	7.0 %	+ 17.6 %	no
12/11/84	01	SO_2	958 ppmv	0.21	yes	83.1	86.9	-	yes^d
12/12/84	02	SO_2	958 ppmv	21.7 %	no	83.1	89.2	3.5 %	yes
12/12/84	03	SO_2	958 ppmv	- 4.53 %	yes	83.1	90.1	3.1 %	yes
12/11/84	01	NO_x	816.1 ppmv	-	-	153	154	-	yes^d
12/12/84	02	NO_x	84.6 ppmv	15.2 %	no	no QC	No QC	No QC	-
12/13/84	03	NO_x	84.6 ppmv	- 5.7 %	yes	21.0	23.1	-	yes^d

TABLE 8-3. SUMMARY OF DRIFT CHECK AND CONTROL STANDARD RESULTS
(cont'd.)

Test Date	Test Run	Parameter	Drift Check		Meets QC?[b]	QC Standard			Meets QC?
			Input Concentration	Instrument Drift %[a]		Input Concentration	Output Concentration	Difference From Running Mean, %	
12/11/84	01	THC	90 ppmv	1.7 %	yes	19.7	20.1	-	yes
12/12/84	02	THC	90 ppmv	- 1.9 %	yes	19.7	20.0	.4	yes
12/13/84	03	THC	90 ppmv			19.7	20.2	.85	yes

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[a] Instrument drift is defined as the percent difference between the instrument response to the input concentration at the beginning and end of the test run.

[b] QC criteria was instrument drift within ± 10 percent.

[c] QC criteria was output concentration within ± 10 percent of the running mean concentration for this test site.

[d] Output concentration within ± 10 percent of known value.

ND[e] Not determined due to calibration gas leakage prior to completion of post test calibration procedure.

Molecular weight was determined by analyzing integrated bag samples of stack gas for CO_2, O_2, and N_2. Quality control for this analysis involved duplicate analyses of calibration gases immediately before and after sample analysis. Analysis of the calibration was to be repeated until two consecutive analyses within ±5 percent were obtained. This same criterion of ±5 percent applied to duplicate analyses required for each sample quantitation. These criteria were met for all molecular weight determinations where valid integrated bag samples were obtained.

8.3 LABORATORY ANALYSIS

QA/QC activities were carried out for dioxin/furan, precursor, and total chloride analyses performed on Site BLB-A samples. The dioxin/furan analyses of MM5 train samples performed by Troika are considered in Section 8.3.1; the precursor analyses of black liquor boiler feed samples performed by Radian/RTP are considered in Section 8.3.2; and the total chloride analyses of HCl train samples and process samples performed by Radian/Austin are considered in Section 8.3.3.

8.3.1 Dioxin/Furan Analyses

Two individual topics related to the dioxin/furan analyses at Site BLB-A are discussed in this section. Analytical recoveries of labeled surrogate compounds spiked onto MM5 train samples are reported in Section 8.3.1.1. Sample blank data are reported in Section 8.3.1.2.

8.3.1.1 Surrogate Recoveries of the Test Samples

Table 8-4 presents the analytical recovery data reported by Troika for four isotopically labeled surrogate compounds spiked onto the MM5 train samples. Samples were spiked with all four of the surrogates. The surrogate recovery results generally met the Tier 4 QA criteria of 50 to 120 percent recovery for the tetrachlorinated surrogates and 40 to 120 percent recovery for the hepta- and octa-chlorinated surrogates.

8.3.1.2 Sample Blanks

Table 8-5 summarizes the analytical results reported by Troika for internal laboratory blanks, laboratory fortified quality control (QC) samples, proof blank MM5 train samples, and field recovery blank MM5 train samples. In general, the data showed good surrogate recoveries, with values

TABLE 8-4. PERCENT SURROGATE RECOVERIES FOR SITE BLB-A DIOXIN/FURAN ANALYSES

Sample	$^{37}Cl_4$ TCDD	$^{13}C_{12}$ TCDD	$^{37}Cl_4$ Hepta-CDD	$^{13}C_{12}$ Octa-CDD
MM5 Train Samples				
Inlet				
Run 01	90	90	55	76
Run 02	100	106	40	66
Run 03	96	62	53	42
Outlet				
Run 01	94	88	47	49
Run 02	85	91	34	51
Run 03	100	98	48	63
Economizer Ash				
a	-	89	-	93

[a] A single economizer ash sample was taken during the pre-survey.

TABLE 8-5. ANALYSIS RESULTS FOR QUALITY CONTROL SAMPLES

Compound	Flue Gas Quality Control Samples: Laboratory Blank	Fortified Laboratory QC Sample: Measured Value	Fortified Laboratory QC Sample: True Value[a,b]	Proof Blank MM5 Train	Field Blank MM5 Train: Inlet	Field Blank MM5 Train: Outlet
	Amount Detected (Nanograms per Sample)					
Dioxins						
2378 TCDD	ND	0.4	0.4 (0)	ND	ND	ND
Other TCDD	ND	ND	ND (0)	ND	ND	ND
Penta CDD	ND	ND	ND (0)	ND	ND	ND
Hexa CDD	ND	1.4	1.6 (-14)	ND	ND	ND
Hepta CDD	ND	3.0	2.4 (20)	ND	ND	0.5
Octa CDD	0.9	3.6	3.2 (-11)	0.5	0.8	1.0
Furans						
2378 TCDF	ND	0.5	0.4 (20)	ND	ND	ND
Other TCDF	ND	ND	ND (0)	ND	0.2	ND
Penta CDF	ND	0.8	0.8 (0)	ND	ND	ND
Hexa CDF	ND	1.2	1.6 (-33)	ND	ND	ND
Hepta CDF	ND	3.1	2.4 (23)	ND	ND	ND
Octa CDF	0.9	3.7	3.2 (14)	ND	ND	ND
	Surrogate Recoveries (Percent)					
$^{37}\text{Cl}_4$-TCDD	94	100	NA	84	86	106
$^{13}\text{C}_{12}$-TCDD	94	92	NA	86	92	102
$^{37}\text{Cl}_4$-Hepta CDD	54	57	NA	47	44	42
$^{13}\text{C}_{12}$-Octa CDD	65	72	NA	79	48	67

[a] True values represent the amounts of each homologue spiked into the laboratory fortified QC samples.

[b] Value shown in parenthesis is the percentage difference between the measured and the true value:

$$\% = \frac{\text{Measured Value} - \text{True Value}}{\text{True Value}} \times 100$$

ND = Not Detected
NA = Not Applicable
TCDD = Tetra-chlorinated dibenzo-p-dioxin

ranging from 42 to 106 percent. Comparison of the measured and spiked values for the laboratory fortified QC samples showed agreement well within the Tier 4 target of ± 50 percent. Dioxin and furan species were non-detectable in the proof blank MM5 train sample except the octa-CDD isomer for which 0.5 ng was detected. Small but detectable quantities of hepta-CDD, octa-CDD and tetra-CDF were found in the field blank MM5 trains. The octa-CDD isomer was detected in the inlet and outlet field blanks in quantities of 0.8 and 1.0 ng, respectively. The tetra-CDF isomer was detected at the inlet but was non-detectable in the outlet field blank. Finally, 0.5 ng of the hepta-CDD isomer was detected at the outlet. Table 8-6 gives a comparison of the dioxin/furan analytical results for the field blank and test run MM5 trains. For the inlet values, only the octa-CDD homologue had a detectable field blank value, equal to 50 percent of the minimum test run value. However, for the outlet data, the hepta-CDD, octa-CDD, and tetra-CDF isomers had reported field blank values equal to 100, 77, and 40 percent of the minimum test run value, respectively. This indicates that there might have been some blanking problems at Site BLB-A. Emissions data reported in Section 5.4 are not blank-corrected.

8.3.2 Precursor Analyses

Table 8-7 presents analytical recovery efficiencies for seven isotopically labeled compounds used as surrogates for the target precursor analytes in the Site BLB-A feed samples. The surrogate recovery values in Table 8-7 vary considerably by specific surrogate species but are fairly uniform between runs for the same species. Several of the recoveries are below the 50 percent objective stated in the Tier 4 QA Project Plan and are below those generally considered achievable when analyzing for similar compounds in water or from MM5 train components. In spite of the relatively low surrogate recovery values for some of the feed samples, the resulting analytical sensitivity for the target analytes was considered acceptable for the purpose of this study.

8.3.3 Total Chloride Analysis

Total chloride analyses were performed by Radian/Austin on the HCl train samples. QA/QC activities include total chloride analysis of field recovery blank HCl train samples and total chloride analysis of an aliquot of NaOH

TABLE 8-6. FIELD BLANK DIOXIN/FURAN DATA FOR SITE BLB-A MM5 SAMPLES

	Amount Detected, Nanograms per Train					
	Field Blank Value		Minimum Test Run Value		Percentage[a]	
Isomer/Homologue	Inlet	Outlet	Inlet	Outlet	Inlet	Outlet
Dioxins						
2378 TCDD	ND	ND	ND	ND	0	0
Other TCDD	ND	ND	0.05	0.3	0	0
Penta CDD	ND	ND	ND	ND	0	0
Hexa CDD	ND	ND	0.2	0.8	0	0
Hepta CDD	ND	0.5	0.5	0.5	0	100
Octa CDD	0.8	1.0	1.6	1.3	50	77
Furans						
2378 TCDF	ND	ND	ND	ND	0	0
Other TCDF	ND	0.2	ND	0.5	0	40
Penta CDF	ND	ND	ND	0.6	0	0
Hexa CDF	ND	ND	ND	1.0	0	0
Hepta CDF	ND	ND	ND	0.3	0	0
Octa CDF	ND	ND	ND	0.2	0	0

[a] Percentage shown is the ratio of the field blank value to the minimum test run value, expressed as a percentage.

TABLE 8-7. PERCENT SURROGATE RECOVERIES FOR SITE BLB-A FEED SAMPLES

Surrogate Compound	Percent Surrogate Recovery			
	Black Liquor Feed			
	Run 01	Run 02	Run 03	Average
d_4-dichlorobenzene	35	100	85	73
bromobiphenyl	114	98	92	101
2',5,5' tetrabromobiphenyl	135	84	80	100
d_6-phenol	ND	12,78,77	25	38
d_4-2-chlorophenol	21	26,104,96	41	58
$^{13}C_6$-pentachlorophenol	92	35,79,68	40	63

solution used in the sample train impinger rinses. Less than 1 mg/l chloride was detected in the aliquot of NaOH solution analyzed, while chloride concentrations of 2 and 1 mg/l were detected in the front and back halves of the field recovery blank train samples, respectively. These values were well below the typical test run values for this site.

APPENDIX A-1

MODIFIED METHOD 5 AND
EPA METHODS 1-4 FIELD RESULTS

```
        R A D I A N   S O U R C E   T E S T
        E P A   M E T H O D   2 - 5
        ( R A W   D A T A )
     PLANT                 : SITE 04
     PLANT SITE            :
     SAMPLING LOCATION     : LOCATION B-ESP INLET
     TEST #                : 04-MM5T-B1
     DATE                  : 12/11/84
     TEST PERIOD           : 1420-2249

   PARAMETER                                  VALUE
   ---------                                  -----

   Sampling time (min.)                        240
   Barometric Pressure (in.Hg)                 29.58
   Sampling nozzle diameter (in.)              .312
   Meter Volume (cu.ft.)                       150.9299
   Meter Pressure (in.H2O)                     1.585208
   Meter Temperature (F)                       80.97916
   Stack dimension (sq.in.)                    15840
   Stack Static Pressure (in.H2O)             -10
   Stack Moisture Collected (gm)               1026.1
   Absolute stack pressure(in Hg)              28.84471
   Average stack temperature (F)               350.9375
   Percent CO2                                 14
   Percent O2                                  5
   Percent N2                                  79
   Delps Subroutine result                     16.92305
   DGM Factor                                  .9947
   Pitot Constant                              .84
```

```
    R A D I A N   S O U R C E   T E S T
    E P A   M E T H O D S   2 - 5
    F I N A L   R E S U L T S
PLANT                : SITE 04
PLANT SITE           :
SAMPLING LOCATION    : LOCATION B-ESP INLET
TEST #               : 04-MM5T-B1
DATE                 : 12/11/84
TEST PERIOD          : 1420-2249

    PARAMETER                RESULT
    ---------                ------

    Vm(dscf)                  145.4338
    Vm(dscm)                  4.118685
    Vw gas(scf)               48.38062
    Vw gas (scm)              1.370139
    % moisture                24.96234
    Md                        .7503766
    MWd                       29.88
    MW                        26.91447
    Vs(fpm)                   2616.968
    Vs (mpm)                  797.8562
    Flow(acfm)                287866.5
    Flow(acmm)                8152.379
    Flow(dscfm)               135588.1
    Flow(dscmm)               3839.854
    % I                       92.64972
    % EA                      31.53381




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```
      R A D I A N   S O U R C E   T E S T
      E P A   M E T H O D   2 - 5
      ( R A W   D A T A )
    PLANT                   : SITE 04
    PLANT SITE              :
    SAMPLING LOCATION       : LOCATION B-ESP INLET
    TEST #                  : 04-MM5T-B2
    DATE                    : 12/12/84
    TEST PERIOD             : 1100-1541

  PARAMETER                                VALUE
  ---------                                -----

  Sampling time (min.)                      144
  Barometric Pressure (in.Hg)               29.52
  Sampling nozzle diameter (in.)            .312
  Meter Volume (cu.ft.)                     93.8
  Meter Pressure (in.H2O)                   1.632083
  Meter Temperature (F)                     88.98959
  Stack dimension (sq.in.)                  15840
  Stack Static Pressure (in.H2O)           -10
  Stack Moisture Collected (gm)             700.2
  Absolute stack pressure(in Hg)            28.78471
  Average stack temperature (F)             353.3542
  Percent CO2                               14
  Percent O2                                5
  Percent N2                                79
  Delps Subroutine result                   16.67247
  DGM Factor                                .9973
  Pitot Constant                            .84
```

```
   R A D I A N   S O U R C E   T E S T
   E P A   M E T H O D S   2 - 5
   F I N A L   R E S U L T S
PLANT                : SITE 04
PLANT SITE           :
SAMPLING LOCATION    : LOCATION B-ESP INLET
TEST #               : 04-MM5T-B2
DATE                 : 12/12/84
TEST PERIOD          : 1100-1541

   PARAMETER                    RESULT
   ---------                    ------

   Vm(dscf)                      89.12821
   Vm(dscm)                      2.524111
   Vw gas(scf)                   33.01443
   Vw gas (scm)                  .9349686
   % moisture                    27.02941
   Md                            .729706
   MWd                           29.88
   MW                            26.66891
   Vs(fpm)                       2592.76
   Vs (mpm)                      790.4756
   Flow(acfm)                    285203.6
   Flow(acmm)                    8076.967
   Flow(dscfm)                   129974.3
   Flow(dscmm)                   3680.871
   % I                           98.72038
   % EA                          31.53381



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RADIAN SOURCE TEST
EPA METHOD 2-5
(RAW DATA)

PLANT : SITE 04
PLANT SITE :
SAMPLING LOCATION : LOCATION B-ESP INLET
TEST # : 04-MM5T-B3
DATE : 12/13/84
TEST PERIOD : 1230-1658

PARAMETER	VALUE
Sampling time (min.)	141
Barometric Pressure (in.Hg)	29.5
Sampling nozzle diameter (in.)	.312
Meter Volume (cu.ft.)	90.3589
Meter Pressure (in.H2O)	1.525532
Meter Temperature (F)	94.31914
Stack dimension (sq.in.)	15840
Stack Static Pressure (in.H2O)	-10
Stack Moisture Collected (gm)	830
Absolute stack pressure(in Hg)	28.76471
Average stack temperature (F)	353.1915
Percent CO2	14
Percent O2	5
Percent N2	79
Delps Subroutine result	16.15068
DGM Factor	.9973
Pitot Constant	.84

```
   R A D I A N   S O U R C E   T E S T
   E P A   M E T H O D S   2 - 5
   F I N A L   R E S U L T S
PLANT                : SITE 04
PLANT SITE           :
SAMPLING LOCATION    : LOCATION B-ESP INLET
TEST #               : 04-MM5T-B3
DATE                 : 12/13/84
TEST PERIOD          : 1230-1658

   PARAMETER                  RESULT
   ---------                  ------

   Vm(dscf)                    84.95314
   Vm(dscm)                    2.405873
   Vw gas(scf)                 39.1345
   Vw gas (scm)                1.108289
   % moisture                  31.53779
   Md                          .6846221
   MWd                         29.88
   MW                          26.13331
   Vs(fpm)                     2538.104
   Vs (mpm)                    773.8123
   Flow(acfm)                  279191.5
   Flow(acmm)                  7906.702
   Flow(dscfm)                 119314.3
   Flow(dscmm)                 3378.981
   % I                         104.6838
   % EA                        31.53381




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```
     R A D I A N   S O U R C E   T E S T
     E P A   M E T H O D   2 - 5
     ( R A W   D A T A )
   PLANT                  :  SITE 04
   PLANT SITE             :
   SAMPLING LOCATION      :  LOCATION C-ESP OUTLET
   TEST #                 :  04-MM5T-C1
   DATE                   :  12/11/84
   TEST PERIOD            :  1420-2020

 PARAMETER
 ---------                                 VALUE
                                           -----

 Sampling time (min.)                       240
 Barometric Pressure (in.Hg)                29.58
 Sampling nozzle diameter (in.)             .309
 Meter Volume (cu.ft.)                      193.1
 Meter Pressure (in.H2O)                    2.264
 Meter Temperature (F)                      91.85714
 Stack dimension (sq.in.)                   12076.31
 Stack Static Pressure (in.H2O)            -.85
 Stack Moisture Collected (gm)              1287.2
 Absolute stack pressure(in Hg)             29.5175
 Average stack temperature (F)              346.72
 Percent CO2                                14
 Percent O2                                 5
 Percent N2                                 77
 Delps Subroutine result                    21.35512
 DGM Factor                                 .9945
 Pitot Constant                             .84
```

```
   R A D I A N   S O U R C E   T E S T
   E P A   M E T H O D S   2 - 5
   F I N A L   R E S U L T S
PLANT                  : SITE 04
PLANT SITE             :
SAMPLING LOCATION      : LOCATION C-ESP OUTLET
TEST #                 : 04-MM5T-C1
DATE                   : 12/11/84
TEST PERIOD            : 1420-2020

   PARAMETER                          RESULT
   ---------                          ------

   Vm(dscf)                            182.6704
   Vm(dscm)                            5.173226
   Vw gas(scf)                         60.69148
   Vw gas (scm)                        1.718783
   % moisture                          24.93878
   Md                                  .7506123
   MWd                                 29.32
   MW                                  26.49693
   Vs(fpm)                             3290.109
   Vs (mpm)                            1003.082
   Flow(acfm)                          275919.3
   Flow(acmm)                          7814.033
   Flow(dscfm)                         133729.4
   Flow(dscmm)                         3787.215
   % I                                 91.70922
   % EA                                32.62005




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```
      R A D I A N   S O U R C E   T E S T
      E P A   M E T H O D   2 - 5
      ( R A W   D A T A )
   PLANT               : SITE 04
   PLANT SITE          :
   SAMPLING LOCATION   : LOCATION C-ESP OUTLET
   TEST #              : 04-MM5T-C2
   DATE                : 12/12/84
   TEST PERIOD         : 1100-1615

 PARAMETER                              VALUE
 ---------                              -----

 Sampling time (min.)                    240
 Barometric Pressure (in.Hg)             29.58
 Sampling nozzle diameter (in.)          .309
 Meter Volume (cu.ft.)                   196.481
 Meter Pressure (in.H2O)                 2.483333
 Meter Temperature (F)                   30.09375
 Stack dimension (sq.in.)                12076.31
 Stack Static Pressure (in.H2O)         -.85
 Stack Moisture Collected (gm)           1394.2
 Absolute stack pressure(in Hg)          29.5175
 Average stack temperature (F)           343.4167
 Percent CO2                             14.1
 Percent O2                              5.6
 Percent N2                              77
 Delps Subroutine result                 20.82071
 DGM Factor                              .9945
 Pitot Constant                          .84
```

```
     R A D I A N   S O U R C E   T E S T
     E P A   M E T H O D S   2 - 5
     F I N A L   R E S U L T S
PLANT                  : SITE 04
PLANT SITE             :
SAMPLING LOCATION      : LOCATION C-ESP OUTLET
TEST #                 : 04-MM5T-C2
DATE                   : 12/12/84
TEST PERIOD            : 1100-1615

     PARAMETER                     RESULT
     ---------                     ------

     Vm(dscf)                       209.4061
     Vm(dscm)                       5.930381
     Vw gas(scf)                    65.73653
     Vw gas (scm)                   1.861658
     % moisture                     23.8918
     Md                             .761082
     MWd                            29.556
     MW                             26.79506
     Vs(fpm)                        3189.879
     Vs (mpm)                       972.5241
     Flow(acfm)                     267513.6
     Flow(acmm)                     7575.986
     Flow(dscfm)                    132004.4
     Flow(dscmm)                    3738.365
     % I                            106.5056
     % EA                           38.02282




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```
       R A D I A N   S O U R C E   T E S T
       E P A   M E T H O D   2 - 5
       ( R A W   D A T A )
    PLANT                 : SITE 04
    PLANT SITE            :
    SAMPLING LOCATION     : LOCATION C-ESP OUTLET
    TEST #                : 04-MM5T-C3
    DATE                  : 12/13/84
    TEST PERIOD           : 0945-1527

  PARAMETER                                   VALUE
  ---------                                   -----

  Sampling time (min.)                         240
  Barometric Pressure (in.Hg)                  29.5
  Sampling nozzle diameter (in.)               .309
  Meter Volume (cu.ft.)                        194.437
  Meter Pressure (in.H2O)                      2.4
  Meter Temperature (F)                        30.69792
  Stack dimension (sq.in.)                     12076.31
  Stack Static Pressure (in.H2O)              -.85
  Stack Moisture Collected (gm)                1511
  Absolute stack pressure(in Hg)               29.4375
  Average stack temperature (F)                341.625
  Percent CO2                                  14.7
  Percent O2                                   4.27
  Percent N2                                   76.9
  Delps Subroutine result                      20.41842
  DGM Factor                                   .9945
  Pitot Constant                               .84
```

```
   RADIAN SOURCE TEST
   EPA METHODS 2-5
   FINAL RESULTS
PLANT                  : SITE 04
PLANT SITE             :
SAMPLING LOCATION      : LOCATION C-ESP OUTLET
TEST #                 : 04-MM5T-C3
DATE                   : 12/13/84
TEST PERIOD            : 0945-1527

   PARAMETER                RESULT
   ---------                ------

   Vm(dscf)                  206.3736
   Vm(dscm)                  5.844499
   Vw gas(scf)               71.24365
   Vw gas (scm)              2.01762
   % moisture                25.66255
   Md                        .7433745
   MWd                       29.3664
   MW                        26.44949
   Vs(fpm)                   3152.89
   Vs (mpm)                  961.247
   Flow(acfm)                264411.6
   Flow(acmm)                7488.137
   Flow(dscfm)               127376.8
   Flow(dscmm)               3607.31
   % I                       108.7766
   % EA                      26.6349




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APPENDIX A-2

CONTINUOUS EMISSION MONITORING RESULTS

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ORRE TED DATA - SITE 04 - TEST 1

FACTOR FOR 3% O2 NORMALIZATION OF OTHER PROCESS GASES	NORMALIZED / CORRECTED DATA - WITH ACTUAL O2						
	TIME	O2 (%V)	CO (PPMV)	CO2 (%V)	SO2 (PPMV)	NOX (PPMV)	THC (PPMV)
1.1603	1445	5.6	33.6	15.6	93.6	66.2	2.6
1.1765	1450	5.7		15.4	124.6	67.0	2.5
1.1831	1455	5.8	130.3				2.5
1.1726	1500	5.6	168.3	16.7	146.3	66.6	2.5
1.1748	1505	5.7	54.6	14.4	101.7	67.8	2.2
1.1699	1510	5.6		15.4	159.5	67.5	18.7
1.1680	1515	5.6	98.8	14.8	137.5	68.4	9.6
1.1661	1520	5.6		14.9	164.2	65.3	2.3
1.1505	1525	5.3		15.5	103.5	65.0	3.6
1.1862	1530	5.8		15.7	204.1	68.1	2.5
1.1547	1535	5.4		16.3	116.6	67.3	2.2
1.1651	1540	5.5	66.2	16.5	91.4	67.4	7.1
1.1788	1545	5.7	120.5	15.0	86.6	67.7	2.1
1.1860	1550	5.8	84.8	14.2	159.6	68.9	2.0
1.1744	1555	5.7	32.9	15.8	198.2	65.4	2.1
1.1711	1600	5.6	45.2	15.3	89.2	65.5	2.2
1.1809	1605	5.7	73.5	16.5	75.5	68.4	2.2
1.1802	1610	5.7	35.3	16.0	83.5	68.2	
1.1774	1615	5.7		16.9	88.8	69.5	
1.1848	1620	5.8		17.2	68.5	70.8	21.3
1.1823	1625	5.8	152.3	17.6	135.1	70.0	11.2
1.1772	1630	5.7		14.8	118.1	68.7	3.8
1.1894	1635	5.9	20.0	16.5	191.1	72.0	2.0
0.0176	1640						
1.1715	1645	5.6		16.3	262.6	68.8	2.0
1.1704	1650	5.6		16.3	281.2	68.8	1.9
1.1904	1655	5.9	137.0	15.8	371.5	72.6	2.4
1.1397	1700	5.2	84.7	16.5	90.7	67.2	1.5
1.1717	1705	5.6		16.6	101.9	68.5	2.9
1.1414	1710	5.2		15.9	24.2	71.4	3.4
1.1946	1715	5.9	218.4	16.8	63.8	73.2	2.0
1.2350	1720	6.4	33.0	16.9	104.9	77.7	1.7
1.2357	1725	6.4	78.6	14.6	94.6	76.0	1.6
1.2247	1730	6.3	261.4	17.2	123.9	75.8	2.4
1.2155	1735	6.2		16.3	73.9	72.8	1.6
1.2033	1740	6.0	11.4	16.7	83.0	72.1	1.5
1.2121	1745	6.1		16.2	131.3	72.7	2.3
1.2113	1750	6.1	248.8	16.5	54.5	75.2	1.6
1.2256	1755	6.3		17.4	257.3	73.5	1.8
1.2465	1800	6.5	36.6	16.4	323.5	75.3	1.8
1.2370	1805	6.4	10.4	14.3	366.4	76.6	1.7
1.1415	1815	5.2		16.5		72.5	7.6
1.1395	1820	5.2	39.9	15.9	18.4	71.1	16.3
1.1953	1830	5.9	157.3	15.7	19.1	76.5	9.4
1.1848	1835	5.8		15.6		75.0	2.0
1.1818	1840	5.8	29.2	16.7	3.2	71.9	1.7
1.1546	1845	5.4	129.8	16.4	0.3	75.7	1.7
1.1822	1850	5.8		16.5	8.2	76.7	
1.2243	1855	6.3		15.7	16.6	76.4	4.9
1.2162	1900	6.2	80.9	17.4	14.4	78.0	4.8
1.2240	1905	6.3	106.7	16.0	27.6	79.1	3.0
1.2277	1910	6.3	201.6	15.7	165.3	77.9	3.1
1.2029	1915	6.0	95.6	17.8	185.4	77.8	1.6
1.2102	1920	6.1	106.6	15.8	257.5	77.6	1.2
1.2152	1925	6.2	1.4	16.8	366.3	77.1	1.2
1.1918	1930	5.9	131.3	15.8	44.8	78.7	1.0
1.1864	1935	5.8	64.4	16.0	49.3	76.9	1.5
1.2090	1940	6.1		16.1	173.9	66.9	1.0
1.1979	1945	6.0		16.2	139.6	78.7	1.7
1.2076	1950	6.1	143.8	16.0	109.6	79.0	1.0
1.1953	1955	5.9		16.7	64.9	79.0	1.0
1.2168	2000	6.2	107.6	16.7	187.0	78.7	0.9
1.2017	2005	6.0		16.6	130.6	77.6	0.8
1.2117	2010	6.1	66.5	16.5	36.3	77.0	
1.1945	2015	5.9	33.5	16.4	15.7	76.3	2.8
1.2126	2020	6.1	78.2	16.7	40.4	78.9	1.9
1.2313	2025	6.4		16.8	27.9	82.2	3.6
1.2264	2030	6.3	197.9	16.3	28.6	82.1	2.2
1.2080	2035	6.1		16.1	20.3	81.6	3.4
1.2065	2040	6.1	6.7	16.3	47.9	37.9	2.6
1.2125	2045	6.1		16.8	326.5	78.5	3.2
1.2028	2050	6.0	3.6	16.7	93.0	81.3	6.9
1.1863	2055	5.8	11.3	17.0	128.6	80.6	1.6
1.1949	2100	5.9	74.8	17.1	219.7	81.6	1.0
1.2217	2105	6.2		16.6	309.6	83.3	1.0
1.2358	2110	6.4		16.8	232.7	83.1	0.9
1.2344	2115	6.4	227.8	17.1	117.2	82.7	0.8
1.2231	2120	6.3	15.8	16.7	87.6	82.6	1.5
1.2212	2125	6.2	15.7	16.8	437.0	80.7	0.9
1.2197	2130	6.2		17.1	100.3	84.8	0.6
1.2078	2135	6.1	92.5	17.1	86.2	85.2	1.0
1.2102	2140	6.1		16.3	19.0	81.2	0.7
1.2043	2145	6.0	2.5	17.4	10.0	85.4	0.8
1.2133	2150	6.1		16.6	8.0	83.3	0.7
1.1801	2155	5.7		16.5	6.2	79.7	1.1
1.1873	2200	5.8	28.5	16.5	9.0	84.2	0.8
1.2020	2205	6.0	119.0	17.8	6.7	85.7	1.5
1.2110	2210	6.1	89.4	17.1	14.1	83.4	2.2
1.2103	2215	6.1	19.9	16.6	0.5	85.8	1.2
1.2269	2220	6.3		16.8		86.5	5.5
1.2225	2225	6.3	142.5	17.4		87.1	1.2
1.2264	2230	6.3	65.3	16.5	9.1	85.5	0.7
1.2208	2235	6.2	6.4	17.2	10.2	84.9	0.7
1.2201	2240	6.2		17.3		72.9	0.7
1.2165	2245	6.2	55.9	16.2	12.7	84.1	2.9
1.2157	2250	6.2	75.6			63.5	3.0

NO. PTS.	95	NO. PTS.	95	60	93	90	94	91
MEAN	1.1976	MEAN	5.9	84.4	16.3	112.1	75.1	2.5
STD. DEV.	.0	STD. DEV.	0.3	65.2	0.8	102.1	7.4	3.6

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CORRECTED DATA - SITE 04 - TEST 2

	FACTOR FOR 3% O2 NORMALIZATION OF OTHER PROCESS GASES	NORMALIZED / CORRECTED DATA - WITH ACTUAL O2						
		TIME	O2 (%V)	CO (PPMV)	CO2 (%V)	SO2 (PPMV)	NOX (PPMV)	THC (PPMV)
	1.1316	1100	5.1	198.3	15.0	81.6	83.7	6.1
	1.1799	1115	5.7	155.2	14.8	90.1	87.9	3.5
	1.1729	1120	5.6	136.5	14.1	62.1	91.5	3.1
	1.1655	1125	5.5	76.5	15.0	68.5	90.6	2.7
	1.1455	1130	5.3		12.4	29.3	90.2	2.8
	1.1481	1135	5.3	250.4	12.7	27.8	90.5	2.7
	1.1612	1140	5.5	288.8	13.9	59.8	89.5	2.6
	1.1430	1145	5.2	328.0	13.0	46.7	86.9	2.8
	1.1661	1150	5.6	137.1	14.8	55.3	102.4	3.9
	1.1582	1155	5.4	232.1	15.4	92.2	88.5	2.7
	1.1447	1200	5.3	319.6	14.3	24.4	90.4	2.6
	1.1462	1205	5.3	192.5	12.3	25.7	92.3	2.7
	1.1508	1210	5.3	134.3	15.3	12.2	95.4	2.7
	1.1594	1215	5.5	152.2	15.0	43.0	93.8	2.3
	1.1619	1220	5.5	133.4	16.3	19.1	93.8	2.2
	1.1639	1225	5.5	181.4	14.1	19.1	93.2	2.1
	1.1437	1230	5.2	161.2	14.1	17.9	92.7	2.0
	1.1637	1235	5.5	314.7	14.7	17.6	93.4	2.0
	1.1540	1240	5.4	154.4	15.2	13.6	91.4	1.8
	1.1651	1245	5.5	267.7	14.0	32.6	92.5	1.9
	1.1634	1250	5.5	153.1	13.4	17.6	91.8	1.8
	1.1633	1255	5.5	64.6	14.8	10.4	89.3	2.1
	1.1678	1300	5.6	181.1	15.5	5.1	92.6	2.0
	1.1759	1305	5.7	184.3	16.3	3.3	92.7	2.4
	1.1631	1310	5.5	203.3	14.5	2.5	93.6	2.0
	1.1724	1315	5.6	98.0	14.3	0.9	94.8	1.8
	1.1830	1320	5.8		14.6	18.1	90.5	17.2
	1.1840	1325	5.8		13.3	15.9	90.5	2.2
	1.1900	1330	5.9	179.7	15.6	40.4	89.6	5.4
	1.1876	1335	5.8	62.1	15.8	39.7	92.0	3.1
	1.2138	1340	6.2	333.6	14.6	56.3	88.5	3.1
	1.1638	1345	5.5		11.8	48.7	87.3	2.0
	1.1947	1350	5.9	117.8	15.5	168.2	87.6	2.0
	1.1864	1355	5.8		14.7	63.8	84.4	1.8
	1.1927	1400	5.9	119.1	14.7	83.4	86.1	1.9
	1.1633	1405	5.5	252.0	13.3	81.1	81.8	1.8
	1.1947	1410	5.9	122.3	15.3	59.7	86.6	1.9
	1.1900	1415	5.9		14.6	59.4	86.3	1.8
	1.1781	1430	5.7		12.1	13.6	81.4	2.3
	1.1739	1435	5.7	69.5	15.1	30.8	81.7	1.9
	1.2887	1440	7.0	118.8	18.7	32.9	90.3	1.8
	1.1725	1445	5.6	141.4	13.4	66.1	80.5	1.6
	1.2071	1450	6.1		12.9	91.1	86.2	3.2
	1.2049	1455	6.0	78.2	13.5	61.2	84.0	2.2
	1.2191	1500	6.2		14.8	157.3	87.7	1.1
	1.2131	1505	6.1	41.2	15.6	28.8	82.8	3.8
	1.3780	1515	7.9		16.0	69.5	100.9	1.8
	1.1770	1520	5.7	43.1	15.6	164.2	86.2	4.0
	1.1886	1525	5.8	58.8	16.2	171.7	86.2	1.9
	1.1940	1530	5.9	75.8	17.5	134.1	86.2	1.7
	1.1894	1535	5.9	60.0	15.0	97.8	86.2	1.9
	1.1834	1540	5.8	145.5	15.0	85.6	82.5	2.2
	1.1846	1605	5.8	106.2	15.9	28.8	87.8	6.1
	1.1740	1620	5.7	191.4	16.7	74.0	84.2	1.8
NO. PTS.	54	NO. PTS.	54	44	54	54	54	54
MEAN	1.1797	MEAN	5.7	159.4	14.7	54.1	89.1	2.8
STD. DEV.	.0	STD. DEV.	0.4	79.4	1.3	43.0	4.5	2.2

CORRECTED DATA - SITE 04 - TEST 3

FACTOR FOR 3% O2 NORMALIZATION OF OTHER PROCESS GASES	NORMALIZED / CORRECTED DATA - WITH ACTUAL O2						
	TIME	O2 (%V)	CO (PPMV)	CO2 (%V)	SO2 (PPMV)	NOX (PPMV)	THC (PPMV)
1.2899	945	7.0	320.7	13.0	144.9	81.0	55.3
1.3077	950	7.2	3.4	14.9	167.9	81.0	12.5
1.2923	955	7.0		14.9	245.4	85.6	10.0
1.2788	1000	6.9	12.2	13.5	165.2	84.7	13.7
1.2728	1005	6.8	143.0	14.2	154.5	86.6	7.4
1.2651	1010	6.8	267.0	16.1	38.5	86.9	5.9
1.2615	1015	6.7	914.1	14.4	119.1	76.1	5.4
1.3276	1020	7.4	34.0	15.2	100.9	87.4	6.8
1.3182	1025	7.3	339.9	16.9	60.9	89.3	5.6
1.3105	1030	7.2	108.8	15.6	79.5	87.4	
1.2557	1055	6.6	51.9	15.6	131.7	84.6	3.9
1.2411	1110	6.5		15.0	208.9	86.2	2.5
1.2486	1115	6.6	370.4	13.9	46.9	84.2	2.7
1.2429	1120	6.5	399.6	15.8	41.9	81.9	8.4
1.2520	1125	6.6	261.0	15.4	56.6	82.7	4.8
1.2427	1130	6.5	235.0	16.1	27.3	86.5	4.5
1.2832	1135	6.9	222.8	14.2	60.4	85.8	3.6
1.2721	1140	6.8	7.5	14.0	132.3	88.0	3.4
1.2845	1155	7.0	41.2	15.8	126.5	89.3	3.5
1.4854	1230	8.8		17.4	84.6	107.5	5.2
1.3169	1235	7.3	114.7	15.5	54.3	97.4	3.5
1.3164	1240	7.3	174.5	15.1	43.5	96.4	3.3
1.2143	1355	6.2	58.4	13.0	122.3	82.7	5.4
1.2228	1400	6.3	202.4	15.4	146.7	86.4	4.3
1.2418	1410	6.5		16.1	120.3	86.2	3.5
1.2465	1415	6.5		16.0	128.2	85.5	3.6
1.2223	1420	6.3	158.4	17.7	61.9	83.6	3.7
1.2140	1425	6.2	111.8	15.3	82.2	85.6	8.5
1.2108	1430	6.1		14.9	80.8	88.0	5.2
1.2135	1435	6.1	198.0	17.5	84.8	85.5	3.9
1.2581	1440	6.7	41.4	16.2	35.7	86.5	3.8
1.2233	1445	6.3	162.0	16.2	153.0	83.6	3.5
1.2269	1450	6.3	165.9	16.1	176.2	82.8	3.7
1.2221	1455	6.3		14.1	139.1	80.3	3.2
1.2358	1500	6.4	121.3	16.4	110.5	84.3	3.0
1.2577	1505	6.7	27.8	15.1	151.7	85.0	2.9
1.2285	1510	6.3	104.1	16.3	257.4	83.9	2.8
1.2135	1515	6.1	59.9	18.6	271.5	82.1	2.8
1.2122	1520	6.1	66.0	15.6	298.1	83.4	2.9
1.2215	1525	6.2	150.4	13.6	196.2	82.3	2.9
1.2495	1530	6.6	318.0	14.7	100.5	81.8	3.2
1.2470	1535	6.5	118.8	14.1	136.5	83.7	3.1
1.2217	1540	6.2	163.6	18.5	255.5	80.2	4.0
1.2659	1545	6.8	20.0	17.1	272.3	85.1	3.2
1.2654	1550	6.8	67.1	16.2	307.7	86.0	3.2
1.2423	1555	6.5	42.2	18.1	227.9	84.6	3.9
1.2521	1600	6.6	130.6	18.4	162.2	86.7	3.2
1.2709	1605	6.8	38.9	19.3	334.9	88.4	3.1
1.2669	1610	6.8	216.6	14.4	388.2	89.6	2.9
1.2062	1615	6.1		16.9	153.0	81.6	2.8
1.2202	1620	6.2	107.9	16.5	68.3	82.6	2.7
1.2463-	1625	6.5	293.5	17.0	141.6	87.0	2.8
1.2426	1630	6.5	34.1	16.2	87.3	85.4	2.8
1.2231	1635	6.3	316.8	15.3	47.7	86.5	2.9
1.2340	1640	6.4	42.1	14.4	119.7	88.8	3.2
1.2251	1645	6.3	156.0	19.2	98.7	88.2	3.0
1.2088	1650	6.1	96.4	16.5	95.0	84.6	3.0
1.2005	1655	6.0	27.5	13.8	63.9	83.2	2.9
1.1919	1700	5.9	66.8	16.2	55.7	84.9	3.1
1.2260	1705	6.3	58.4	16.7	83.3	84.9	3.0
1.2012	1710	6.0	366.9	18.0	16.4	83.3	2.7
1.2095	1715	6.1	151.9	16.2	75.5	83.1	2.6
1.2053	1720	6.0	435.9	16.4	18.8	83.3	2.3
1.2078	1725	6.1	47.8	16.7	63.8	84.5	3.0
1.2490	1730	6.6	33.0	15.2	61.0	90.8	3.0
1.2342	1735	6.4	171.2	17.1	12.6	88.3	2.6
1.2425	1740	6.5		14.4	24.4	88.8	2.3
1.2163	1745	6.2	400.2	15.5	4.5	83.9	2.2
1.2215	1750	6.2		16.5	6.5	82.8	9.6
1.2307	1755	6.4	270.5	18.3	3.9	83.0	3.0
1.2077	1800	6.1	143.9	16.0	8.6	78.4	3.0
1.2199	1805	6.2	277.9	17.9	20.9	80.9	0.7
NO. PTS. 72	NO. PTS.	72	62	72	72	72	71
MEAN 1.2473	MEAN	6.5	165.5	15.9	117.0	85.4	4.8
STD. DEV. .0	STD. DEV.	0.5	149.2	1.4	85.2	4.3	6.5

APPENDIX A-3

HCl TRAIN RESULTS

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        RADIAN SOURCE TEST
        EPA METHOD 2-5
        (RAW DATA)
     PLANT                  : SITE 04
     PLANT SITE             :
     SAMPLING LOCATION      : LOCATION C-ESP OUTLET
     TEST #                 : 04-HCL-C-01
     DATE                   : 12/11/84
     TEST PERIOD            : 1425-1719

   PARAMETER                                   VALUE
   ---------                                   -----

   Sampling time (min.)                        174
   Barometric Pressure (in.Hg)                 29.58
   Sampling nozzle diameter (in.)              .305
   Meter Volume (cu.ft.)                       144.175
   Meter Pressure (in.H2O)                     2.483333
   Meter Temperature (F)                       95.86111
   Stack dimension (sq.in.)                    12076.31
   Stack Static Pressure (in.H2O)             -.85
   Stack Moisture Collected (gm)               914.9
   Absolute stack pressure(in Hg)              29.5175
   Average stack temperature (F)               344.8333
   Percent CO2                                 14.7
   Percent O2                                  4.27
   Percent N2                                  76.9
   Delps Subroutine result                     21.11785
   DGM Factor                                  1.0037
   Pitot Constant                              .84
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   R A D I A N   S O U R C E   T E S T
   E P A   M E T H O D S   2 - 5
   F I N A L   R E S U L T S
PLANT                : SITE 04
PLANT SITE           :
SAMPLING LOCATION    : LOCATION C-ESP OUTLET
TEST #               : 04-HCL-C-01
DATE                 : 12/11/84
TEST PERIOD          : 1425-1719

    PARAMETER                  RESULT
    ---------                  ------

    Vm(dscf)                    136.7322
    Vm(dscm)                    3.872256
    Vw gas(scf)                 43.13754
    Vw gas (scm)                1.221655
    % moisture                  23.98265
    Md                          .7601735
    MWd                         29.3664
    MW                          26.64044
    Vs(fpm)                     3244.78
    Vs (mpm)                    989.2621
    Flow(acfm)                  272117.8
    Flow(acmm)                  7706.377
    Flow(dscfm)                 133880
    Flow(dscmm)                 3791.481
    % I                         97.07468
    % EA                        26.6349


                                          Program Revision:1/16/
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RADIAN SOURCE TEST
EPA METHOD 2-5
(RAW DATA)

PLANT : SITE 04
PLANT SITE :
SAMPLING LOCATION : LOCATION C-ESP OUTLET
TEST # : 04-HCL-C-02
DATE : 12/12/84
TEST PERIOD : 1535-1705

PARAMETER	VALUE
Sampling time (min.)	100
Barometric Pressure (in.Hg)	29.58
Sampling nozzle diameter (in.)	.305
Meter Volume (cu.ft.)	80.706
Meter Pressure (in.H2O)	2.31
Meter Temperature (F)	31.7
Stack dimension (sq.in.)	12076.31
Stack Static Pressure (in.H2O)	-.85
Stack Moisture Collected (gm)	547.4
Absolute stack pressure(in Hg)	29.5175
Average stack temperature (F)	340.9
Percent CO2	14.7
Percent O2	4.27
Percent N2	76.9
Delps Subroutine result	20.45646
DGM Factor	1.0037
Pitot Constant	.84

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   R A D I A N   S O U R C E   T E S T
   E P A   M E T H O D S   2 - 5
   F I N A L   R E S U L T S
PLANT                  : SITE 04
PLANT SITE             :
SAMPLING LOCATION      : LOCATION C-ESP OUTLET
TEST #                 : 04-HCL-C-02
DATE                   : 12/12/84
TEST PERIOD            : 1535-1705

   PARAMETER                   RESULT
   ---------                   ------

   Vm(dscf)                     86.49016
   Vm(dscm)                     2.449401
   Vw gas(scf)                  25.80991
   Vw gas (scm)                 .7309367
   % moisture                   22.98299
   Md                           .7701701
   MWd                          29.3664
   MW                           26.75406
   Vs(fpm)                      3136.474
   Vs (mpm)                     956.2419
   Flow(acfm)                   263034.9
   Flow(acmm)                   7449.148
   Flow(dscfm)                  131757
   Flow(dscmm)                  3731.357
   % I                          108.5658
   % EA                         26.6349



                                         Program Revision:1/16/
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        R A D I A N   S O U R C E   T E S T
        E P A   M E T H O D   2 - 5
        ( R A W   D A T A )
    PLANT                    : SITE 04
    PLANT SITE               :
    SAMPLING LOCATION        : LOCATION C-ESP OUTLET
    TEST #                   : 04-HCL-C-03
    DATE                     : 12/13/84
    TEST PERIOD              : 0945-1145

  PARAMETER                                      VALUE
  ---------                                      -----

  Sampling time (min.)                            120
  Barometric Pressure (in.Hg)                     29.5
  Sampling nozzle diameter (in.)                  .305
  Meter Volume (cu.ft.)                           96.01196
  Meter Pressure (in.H2O)                         2.233333
  Meter Temperature (F)                           34.04167
  Stack dimension (sq.in.)                        12076.31
  Stack Static Pressure (in.H2O)                 -.85
  Stack Moisture Collected (gm)                   710.1
  Absolute stack pressure(in Hg)                  29.4375
  Average stack temperature (F)                   341.1667
  Percent CO2                                     14.7
  Percent O2                                      4.27
  Percent N2                                      76.9
  Delps Subroutine result                         20.1104
  DGM Factor                                      1.0037
  Pitot Constant                                  .84
```

```
       R A D I A N   S O U R C E   T E S T
       E P A   M E T H O D S   2 - 5
       F I N A L   R E S U L T S
   PLANT                   : SITE 04
   PLANT SITE              :
   SAMPLING LOCATION       : LOCATION C-ESP OUTLET
   TEST #                  : 04-HCL-C-03
   DATE                    : 12/13/84
   TEST PERIOD             : 0945-1145

      PARAMETER                   RESULT
      ---------                   ------

      Vm(dscf)                     102.1106
      Vm(dscm)                     2.891773
      Vw gas(scf)                  33.48121
      Vw gas (scm)                 .9481879
      % moisture                   24.69265
      Md                           .7530735
      MWd                          29.3664
      MW                           26.55974
      Vs(fpm)                      3098.876
      Vs (mpm)                     944.7794
      Flow(acfm)                   259881.9
      Flow(acmm)                   7359.854
      Flow(dscfm)                  126900.6
      Flow(dscmm)                  3593.826
      % I                          110.8986
      % EA                         26.6349




                                         Program Revision:1/16/
      RADIAN SOURCE TEST
      EPA METHOD 2-5
      (RAW DATA)
    PLANT                    : SITE 04
    PLANT SITE               :
    SAMPLING LOCATION        : LOCATION C-ESP OUTLET
    TEST #                   : 04-HCL-C-04
    DATE                     : 12/13/84
    TEST PERIOD              : 1435-1628

  PARAMETER
  ---------                                  VALUE
                                             -----

  Sampling time (min.)                        113
  Barometric Pressure (in.Hg)                 29.5
  Sampling nozzle diameter (in.)              .305
  Meter Volume (cu.ft.)                       96.01196
  Meter Pressure (in.H2O)                     2.258334
  Meter Temperature (F)                       33.66667
  Stack dimension (sq.in.)                    12076.31
  Stack Static Pressure (in.H2O)             -.85
  Stack Moisture Collected (gm)               667.3
  Absolute stack pressure(in Hg)              29.4375
  Average stack temperature (F)               340.5
  Percent CO2                                 14.7
  Percent O2                                  4.27
  Percent N2                                  76.9
  Delps Subroutine result                     20.2647
  DGM Factor                                  1.0037
  Pitot Constant                              .84
```

```
       R A D I A N   S O U R C E   T E S T
       E P A   M E T H O D S   2 - 5
       F I N A L   R E S U L T S
PLANT                : SITE 04
PLANT SITE           :
SAMPLING LOCATION    : LOCATION C-ESP OUTLET
TEST #               : 04-HCL-C-04
DATE                 : 12/13/84
TEST PERIOD          : 1435-1628

    PARAMETER                  RESULT
    ---------                  ------

    Vm(dscf)                    102.1945
    Vm(dscm)                    2.894148
    Vw gas(scf)                 31.4632
    Vw gas (scm)                .8910377
    % moisture                  23.54013
    Md                          .7645987
    MWd                         29.3664
    MW                          26.69074
    Vs(fpm)                     3114.981
    Vs (mpm)                    949.6891
    Flow(acfm)                  261232.4
    Flow(acmm)                  7398.102
    Flow(dscfm)                 129620.2
    Flow(dscmm)                 3670.843
    % I                         115.3922
    % EA                          26.6349




                                       Program Revision:1/16/
```

APPENDIX B

PROCESS MONITORING DATA

APPENDIX B-1

HOURLY AVERAGE VALUES OF BOILER OPERATING PARAMETERS

Table 1. Hourly Average Values[a] of Various Boiler Parameters, Run #1

Time[b]	Boiler Load 10^3lb/hr	Boiler Oxygen $\%O_2$[d]	Stack Oxygen[e] $\%O_2$	Stack CO[f] ppmCO	Black Liq. Flow gpm	Black Liq. % Solids wt%	Stack TRS[g] ppm@8.70	Stack Opacity (%)
1500	396	3.6	5.9	1.6	258	64.9	3.8	15.0
1600	385	4.1	6.0	6.2	255	65.2	3.7	15.0
1700	388	4.0	6.3	0.7	253	65.5	4.2	15.1
1800	401	4.0	6.5	3.2	254	65.7	4.2	15.0
1900	382	4.4	6.5	1.8	259	65.8	4.0	15.0
2000	391	4.3	6.3	1.8	259	65.8	4.1	15.1
2100	387	4.3	6.9	2.5	257	65.9	4.1	15.0
2200	384	4.0	6.9	5.6	256	66.0	3.9	14.7
2300	390	3.8	6.7	9.6	255	66.0	4.2	14.9
AVG	389	4.1	6.4	3.7	256	65.6	4.0	15.0

a. Values shown in units used by host plant to convert

from:	to:	multiply by:
lb/hr	kg/hr	0.454
gpm	cumeter/min	0.00379

b. Value shown for time "t" is the average value for the one hour period preceding time "t"

c. Boiler load in 10^3lb/hr steam @ 914.7 psi, 1360°R (1452 Btu/lb)

d. Boiler oxygen measured in superheater section

e. Stack oxygen measured at ESP outlet stack (wet basis)

f. Stack CO measured at ESP outlet stack (wet basis, O_2 as measured)

g. Stack TRS measured at ESP Outlet stack (dry basis, corrected to 8% O_2)

Table 2. Hourly Average Values[a] of Various Boiler Parameters, Run #2

Time[b]	Boiler Load[c] 10^3lb/hr	Boiler Oxygen[d] %O_2	Black Liq. Flow gpm	Black Liq. % Solids wt%	Stack Oxygen[e] %O_2	Stack CO[f] ppmv	Stack TRS[g] ppm^v@8%O_2	Stack Opacity %)
1100	388	3.8	254	65.6	cal	33.5	cal	14.9
1200	391	3.3	256	65.6	cal	57.2	cal	15.1
1300	386	3.6	255	65.6	cal	24.1	cal	15.1
1400	391	3.6	254	65.5	5.9	10.9	4.2	14.6
1500	390	3.8	254	65.5	5.9	3.3	4.4	15.1
1600	380	3.4	253	65.6	6.0	3.3	4.7	14.9
1700	398	3.7	253	65.6	6.1	5.5	4.6	14.9
Avg	389	3.6	254	65.6	6.0	17.4	4.5	15.0

cal = no data available for O_2, TRS. Instrument calibrations in progress by host plant.

a. Values shown in units used by host plant to convert

from:	to:	multiply by:
lb/hr	kg/hr	0.454
gpm	cumeter/min	0.00379

b. Value shown for time "t" is the average value for the one hour period preceding time "t"

c. Boiler load in 10^3lb/hr steam @ 914.7 psi, 1360°R (1452 Btu/lb)

d. Boiler oxygen measured in superheater section

e. Stack oxygen measured at ESP outlet stack (wet basis)

f. Stack CO measured at ESP outlet stack (wet basis, O_2 as measured)

g. Stack TRS measured at ESP Outlet stack (dry basis, corrected to 8% O_2)

Table 3. Hourly Average Values[a] of Various Boiler Parameters, Run #3

Time[b]	Boiler Load[c] 10^3lb/hr	Boiler Oxygen[d] $\%O_2$	Black Liq. Flow gpm	Black Liq. % Solids wt%	Stack Oxygen[e] $\%O_2$	Stack CO[f] ppmv	Stack TRS[g] $ppm^v @8\%O_2$	Stack Opacity %)
1000	390	3.6	261	64.3	cal	53	cal	14.9
1100	382	3.1	263	64.0	cal	71	cal	15.0
1200	393	2.8	265	63.6	5.9	86	3.1	15.0
1300	384	2.9	265	63.5	5.4	96	3.3	15.1
1400	386	2.8	265	63.5	5.5	55	3.7	14.8
1500	387	2.9	264	63.5	5.4	79	3.6	14.9
1600	ND	ND	ND	ND	ND	ND	ND	ND
1700	ND	ND	ND	ND	ND	ND	ND	ND
1800	403	3.6	263	63.8	5.4	16	3.9	15.0
Mean	389	3.1	264	63.7	5.5	65	3.5	15.0

cal = no data available for O_2, TRS. Instrument calibrations in progress by plant personnel.

ND = No data available due to computer failure.

a. Values shown in units used by host plant to convert

from:	to:	multiply by:
lb/hr	kg/hr	0.454
gpm	cumeter/min	0.00379

b. Value shown for time "t" is the average value for the one hour period preceding time "t"

c. Boiler load in 10^3lb/hr steam @ 914.7 psi, 1360°R (1452 Btu/lb)

d. Boiler oxygen measured in superheater section

e. Stack oxygen measured at ESP outlet stack (wet basis)

f. Stack CO measured at ESP outlet stack (wet basis, O_2 as measured)

g. Stack TRS measured at ESP Outlet stack (dry basis, corrected to 8% O_2)

APPENDIX B-2

PLANT COMPUTER OUTPUT OF PROCESS DATA

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```
LOG IDENT -     455      TITLE - DIOXIN TEST                          TIME    2300    DATE    12-11-84

                                         ENGR.  CURRENT          CURRENT AVERAGES
POINT              DESCRIPTION           UNITS   VALUE       HOUR      SHIFT      DAY

RCF3264    CMPN STM OUTLET FLOW 3RB   MLB/HR   378.8       389.8      388.9     386.9
RAC3102    CNTRL BOILER OUTLET O2     %          4.161       3.776      4.099     3.722
RTI3069    PRI SHTR INLT FLU GAS TP   DEG F    923.5       937.6      942.8     947.5
RTI3078    INDICATE PRI SCAH OUTLET   DEG F    303.5       303.7      305.1     306.0
RFC3087    CONTROL PRIMARY AIR FLOW   MCFM      61.46       61.25      60.85     59.25
RFC3089    CONTROL SECONDARY AIR FL   MCFM      73.55       73.70      72.44     70.54
RFC3091    CONTROL TERTIARY AIR FLW   MCFM      42.08       43.29      42.53     42.31
RFC3201    CONTROL TER BNRS AIR FLW   MCFM       6.737       6.870      7.146     7.233

RFI3741    PRMRY BLK LIQ NOZ FLOW     GPM      254.4       254.7      255.8     257.6
RDI3748    %SOLID NOZZLE DENSITY #1   %SOLID    66.02       66.02      65.81     65.02
RTC3746    CNTRL BLK LIQR NOZ TEMP    DEG F    216.9       216.7      216.9     217.0
RPC3751    CONTRL BLK LIQR NOZ PRES   PSIG      40.01       39.97      39.99     39.77

RFI3234    INDCTE EPCP OUTLET FLOW    MCFM     116.9       110.4      109.0     108.6
RFI3231    INDCTE WPCP OUTLET FLOW    MCFM     117.9       113.4      110.9     110.7
RTI3228    EAST PCP OUTLET TEMP       DEG F    346.5       346.7      346.2     345.6
RTI3227    WEST PCP OUTLET TEMP       DEG F    347.0       346.7      347.4     346.6
RAI3233    INDCTE E PCP OTLET CAPAC   %         25.25       24.64      25.52     25.83
RAI3232    INDCTE W PCP OTLET CAPAC   %         13.22       13.56      13.01     12.90

RAI3245    INDICATE NO3RB STACK CO    PPM       18.11        9.620      3.607    23.46
R3TRSC     3RB CORRECTED TRS CONCEN   PPM        4.233       4.206      4.102     5.448
RAC3207AF  6 MIN OPACITY ALARM R3     PCT       15.31       14.92      14.97     14.96
RAI3235    #3 RB STACK O2 INDICATE    %          6.668       6.683      6.580     8.610
```

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```
LOG IDENT -    455      TITLE - DIOXIN TEST                    TIME   1630   DATE   12-12-84

                                        ENGR.  CURRENT          CURRENT AVERAGES
 POINT           DESCRIPTION            UNITS   VALUE        HOUR      SHIFT       DAY

RCF3264   CMPN STM OUTLET FLOW 3RB MLB/HR  364.8       398.0      398.0      389.0
RAC3102   CNTRL BOILER OUTLET O2   %         3.833       3.727      3.727      3.698
RTI3069   PRI SHTR INLT FLU GAS TP DEG F   905.0       900.8      900.8      907.9
RTI3078   INDICATE PRI SCAH OUTLET DEG F   306.8       307.4      307.4      306.3
RFC3087   CONTROL PRIMARY AIR FLOW MCFM     58.99       58.31      58.31      58.67
RFC3089   CONTROL SECONDARY AIR FL MCFM     71.01       71.04      71.04      71.28
RFC3091   CONTROL TERTIARY AIR FLW MCFM     43.13       43.12      43.12      43.23
RFC3201   CONTROL TER BNRS AIR FLW MCFM      1.777       1.799      1.799      3.121

RFI3741   PRMRY BLK LIQ NOZ FLOW   GPM     255.2       253.0      253.0      254.1
RDI3748   %SOLID NOZZLE DENSITY #1 %SOLID   65.51       65.59      65.59      65.57
RTC3746   CNTRL BLK LIQR NOZ TEMP  DEG F   218.2       216.6      216.6      216.9
RPC3751   CONTRL BLK LIQR NOZ PRES PSIG     39.99       39.98      39.98      39.98


RFI3234   INDCTE EPCP OUTLET FLOW  MCFM    108.7       105.0      105.0      109.1
RFI3231   INDCTE WPCP OUTLET FLOW  MCFM    109.8       105.2      105.2      110.4
RTI3228   EAST PCP OUTLET TEMP     DEG F   344.5       343.9      343.9      345.7
RTI3227   WEST PCP OUTLET TEMP     DEG F   345.0       344.6      344.6      346.3
RAI3233   INDCTE E PCP OTLET CAPAC %        25.09       25.62      25.62      24.49
RAI3232   INDCTE W PCP OTLET CAPAC %        13.08       12.75      12.75      13.64


RAI3245   INDICATE NO3RB STACK CO  PPM       1.574       5.489      5.489     26.10
R3TRSC    3RB CORRECTED TRS CONCEN PPM       4.390       4.608      4.608      5.079
RAC3207AF 6 MIN OPACITY ALARM R3   PCT      14.86       14.91      14.91      14.95
RAI3235   #3 RB STACK O2 INDICATE  %         5.683       6.129      6.129     12.56
```

```
                                                                     TIME   1730   DATE   12-13-84
LOG IDENT -   455     TITLE - DIOXIN TEST
                                        ENGR.  CURRENT          CURRENT AVERAGES
POINT             DESCRIPTION           UNITS   VALUE      HOUR      SHIFT       DAY

RCF3264    CMPN STM OUTLET FLOW 3RB MLB/HR  408.9      402.7     384.0      387.3
RAC3102    CNTRL BOILER OUTLET O2   %         3.139      3.567     3.545      3.049
RTI3069    PRI SHTR INLT FLU GAS TP DEG F   942.1      935.5     932.3      947.2
RTI3078    INDICATE PRI SCAH OUTLET DEG F   309.2      309.8     309.8      308.5
RFC3087    CONTROL PRIMARY AIR FLOW MCFM     57.36      56.46     56.00      56.51
RFC3089    CONTROL SECONDARY AIR FL MCFM     70.68      70.34     69.82      70.29
RFC3091    CONTROL TERTIARY AIR FLW MCFM     41.44      41.68     41.31      41.61
RFC3201    CONTROL TER BNRS AIR FLW MCFM      1.595      1.739     1.766      1.653

RFI3741    PRMRY ALK LIQ NOZ FLOW   GPM     261.4      263.3     263.2      263.1
RDI3748    %SOLID NOZZLE DENSITY #1 %SOLID   63.95      63.78     63.55      63.77
RTC3746    CNTRL ALK LIQR NOZ TEMP  DEG F   217.2      217.2     217.2      217.2
RPC3751    CONTRL ALK LIQR NOZ PRES PSIG     40.01      39.99     39.99      39.98



RFI3234    INDCTE EPCP OUTLET FLOW  MCFM    100.9      100.0     102.2      107.1
RFI3231    INDCTE WPCP OUTLET FLOW  MCFM    102.6      103.2     103.1      108.7
RTI3228    EAST PCP OUTLET TEMP     DEG F   348.0      343.9     344.2      346.0
RTI3227    WEST PCP OUTLET TEMP     DEG F   347.3      342.7     343.2      346.0
RAI3233    INDCTE E PCP OTLET CAPAC %        23.54      26.80     26.61      24.64
RAI3232    INDCTE W PCP OTLET CAPAC %        11.90      12.63     13.41      13.66


RAI3245    INDICATE NO3RB STACK CO  PPM      37.51      16.00     27.33      67.09
R3TRSC     3RB CORRECTED TRS CONCEN PPM       3.682      3.887     3.627      4.145
RAC3207AF  6 MIN OPACITY ALARM R3   PCT      14.90      14.96     14.89      14.94
RAI3235    #3 RB STACK O2 INDICATE  %         5.108      5.399     5.259      8.665
```

APPENDIX B-3

ELECTROSTATIC PRECIPITATOR ELECTRICAL DATA

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Table 5. Electrostatic Precipitator Electrical Data for Site 04

Parameter[a,b]	Run 01		Run 02		Run 03	
	1445	2140	1310	1625	1020	-
West Inlet						
Voltage	36	38	37	36	35	ND
Current	175	150	150	175	175	ND
West Center						
Voltage	38	38	38	38	37	ND
Current	300	300	325	325	325	ND
West Outlet						
Voltage	35	35	35	35	34	ND
Current	275	250	250	325	300	ND
East Inlet						
Voltage	34	35	35	34	34	ND
Current	250	225	225	250	275	ND
East Center						
Voltage	38	37	37	36	37	ND
Current	175	175	175	200	225	ND
East Outlet						
Voltage	37	37	37	37	37	ND
Current	250	225	250	300	275	ND

---

a. All voltage and current values are DC. Voltage in kv, current in mA.
b. Precipitator was set in opacity control mode during all test runs.

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APPENDIX B-4

DAILY CALIBRATION DATA FOR PLANT-MAINTAINED TRS AND O_2 MONITORS

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0954     12-11-84       PAGE PRINT       CONSOLE    4
                                                            09:54:08  12-11-84
RA13236            388 STACK TRS              TIME : 09:53
6 MIN. AVERAGE  09HR      08HR      07HR      06HR      05HR      04HR      03HR      02HR
            57            18.20     17.18     4.713     4.459     3.749     3.903     4.187
            51  19.30     17.89     16.09     5.044     4.874     4.252     4.958     3.592
            45  18.11     17.89     11.14     4.598     4.694     5.082     5.342     4.164
            39  18.31     18.03     .3365     4.583     4.540     4.751     5.142     4.031
PPM         33  17.81     17.56     4.193     4.093     4.075     5.181     5.124     4.812
            27  19.37     17.93     4.524     4.232     4.288     4.291     4.981     4.911
            21  18.34     18.18     4.662     4.783     4.791     5.113     4.656     4.747
            15  17.88     17.79     4.550     4.605     4.990     4.950     5.262     5.272
            09  18.08     17.94     4.295     4.410     4.595     4.684     4.777     5.122
            03  17.44     17.68     4.584     4.125     4.556     4.687     5.028     5.067
HOUR AVERAGE    09HR      08HR      07HR      06HR      05HR      04HR      03HR      02HR
                19.13     17.98     8.014     4.553     4.564     4.649     4.898     4.555
                01HR      00HR      23HR      22HR      21HR      20HR      19HR      18HR
                4.869     4.618     4.380     4.230     4.404     4.552     4.292     4.378
                17HR      16HR      15HR      14HR      13HR      12HR      11HR      10HR
                4.459     4.105     4.295     4.343     4.024     3.903     4.104     7.920 .
DAY AVERAGE     MON 10    SUN 09    SAT 08    FRI 07    THU 06    WED 05    TUE 04
                5.265     4.285     4.371     4.043     4.860     4.080     3.780
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   0994    12-11-88      PAGE PRINT      CONSOLE    4
                                                             09:54:40  12-11-88

RAI3235          #3 RB STACK O2 INDICATE     TIME : 09:54

6 MIN. AVERAGE   09HR     08HR     07HR     06HR     05HR     04HR     03HR     02HR

            57             21.08    21.06    5.656    5.839    5.886    5.526    5.751

            51   21.07    21.03    21.03    5.711    5.429    5.846    7.410    6.455

            45   21.07    21.03    21.01    5.880    5.422    5.560    5.344    5.910

            39   21.06    21.05    20.92    5.974    5.539    5.518    5.291    5.935

x           33   21.05    21.06    6.959    6.786    5.896    5.616    5.353    5.780

            27   21.02    21.06    5.674    6.118    5.649    7.630    5.543    5.720

            21   21.02    21.07    5.722    5.910    5.600    5.810    6.737    5.998

            15   21.02    21.07    5.779    6.008    5.603    5.939    5.668    5.919

            09   21.02    21.07    7.276    6.032    5.652    6.014    5.536    5.741

            03   21.03    21.07    5.608    5.883    5.673    5.374    5.651    5.695

HOUR AVERAGE     09HR     08HR     07HR     06HR     05HR     04HR     03HR     02HR

                 20.74    21.04    13.13    5.975    5.596    5.942    5.776    5.872

                 01HR     00HR     23HR     22HR     21HR     20HR     19HR     18HR

                 5.874    6.368    6.255    5.935    5.963    6.231    6.116    5.957

                 17HR     16HR     15HR     14HR     13HR     12HR     11HR     10HR

                 6.201    6.428    6.089    6.491    6.573    6.821    6.443    10.73

DAY AVERAGE     MON 10   SUN 09   SAT 08   FRI 07   THR 06   WED 05   TUE 04

                 7.275    6.713    7.164    9.093    9.289    8.438    7.586
```

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     1128     12-12-84       PAGE PRINT       CONSOLE    3
84                                                             11:28:12  12-12-84
8413236          388 STACK TRS                TIME : 11:27
6 MIN. AVERAGE  11HR     10HR     09HR     08HR     07HR     06HR     05HR     04HR
            57           17.47    17.59    17.71    17.19    5.726    5.784    5.383
            51           17.69    17.75    17.44    15.94    5.423    5.315    5.238
            45           17.66    17.68    17.61    8.340    5.332    5.575    4.622
            39           17.55    17.21    17.08    3.143    4.997    5.191    5.246
PPM         33           17.85    17.76    17.76    5.634    5.226    5.058    4.562
            27  17.64    17.53    17.68    17.70    5.394    5.747    5.831    5.159
            21  17.81    17.75    17.46    17.31    5.484    5.098    5.800    5.309
            15  17.53    17.62    17.60    17.57    5.343    5.885    5.332    5.073
            09  17.61    17.42    17.16    17.16    5.093    5.397    5.239    5.107
            03  17.97    17.97    17.80    17.60    5.444    4.865    4.430    4.777
HOUR AVERAGE    11HR     10HR     09HR     08HR     07HR     06HR     05HR     04HR
                17.67    17.64    17.57    17.50    8.475    5.412    5.419    5.028
                03HR     02HR     01HR     00HR     23HR     22HR     21HR     20HR
                5.196    5.257    4.993    5.072    5.002    4.806    4.628    4.294
                19HR     18HR     17HR     16HR     15HR     14HR     13HR     12HR
                4.169    4.496    4.534    4.490    4.889    4.314    4.419    4.218
DAY AVERAGE     TUE 11   MON 10   SUN 09   SAT 08   FRI 07   THR 06   WED 05
                5.848    5.265    4.285    4.371    4.043    4.860    4.040
```

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    1128    12-12-84      PAGE PRINT      CONSOLE    3
                                                                  11:28:40  12-12-84

9AI3235         #3 RB STACK O2 INDICATE    TIME : 1128

6 MIN. AVERAGE  11HR    10HR    09HR    08HR    07HR    06HR    05HR    04HR

           57           21.10   21.11   21.08   21.10   6.315   6.199   6.170

           51           21.11   21.11   21.08   21.09   6.305   6.301   6.018

           45           21.11   21.10   21.09   21.06   6.372   6.342   5.997

           39           21.12   21.10   21.09   18.36   7.436   6.321   6.315

x          33           21.12   21.10   21.10   6.371   6.247   6.437   6.388

           27   20.88   21.11   21.10   21.10   6.440   6.354   6.199   7.287

           21   21.11   21.11   21.10   21.10   6.419   6.608   6.364   6.375

           15   21.11   21.11   21.09   21.11   6.453   6.267   6.341   6.319

           09   21.11   21.11   21.09   21.11   8.410   6.125   6.100   6.323

           03   21.11   21.11   21.09   21.10   6.321   6.995   6.299   6.297

HOUR AVERAGE    11HR    10HR    09HR    08HR    07HR    06HR    05HR    04HR

                20.51   21.10   21.09   21.08   13.18   6.495   6.296   6.349

                03HR    02HR    01HR    00HR    23HR    22HR    21HR    20HR

                6.578   6.455   6.407   6.780   6.652   6.696   6.683   6.947

                19HR    18HR    17HR    16HR    15HR    14HR    13HR    12HR

                6.864   6.335   6.505   6.470   6.261   5.984   5.853   6.232

DAY AVERAGE    TUE 11  MON 10  SUN 09  SAT 08  FRI 07  THR 06  WED 05

                7.826   7.275   6.713   7.164   9.093   9.249   8.438
```

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1149     12-13-84       PAGE PRINT       CONSOLE    4
                                                              11:49:32  12-13-84

4413236         3RB STACK TRS                  TIME : 11:48

6 MIN. AVERAGE  11HR     10HR     09HR     08HR     07HR     06HR     05HR     04HR

           57            3.997    3.444    17.24    .0823    5.189    4.340    4.909

           51            3.193    2.982    17.07    .0135    5.035    4.293    5.473

           45   4.324    3.838    3.809    17.18    .1490    4.354    4.250    4.891

           39   4.203    3.450    3.730    17.42    3.706    4.758    4.148    4.770

PPM        33   3.663    3.490    3.874    16.88    4.829    4.734    4.582    4.575

           27   3.492    3.488    12.53    16.97    4.443    4.533    4.354    4.708

           21   3.794    2.702    17.24    17.03    4.588    4.510    4.841    4.765

           15   4.304    4.303    17.18    16.55    3.620    4.297    4.467    5.051

           09   4.157    4.043    17.44    16.37    5.069    4.448    5.050    4.565

           03   3.833    3.934    17.15    14.04    5.042    4.943`   5.279    4.321

HOUR AVERAGE    11HR     10HR     09HR     08HR     07HR     06HR     05HR     04HR

                3.990    3.645    9.064    16.91    3.701    4.694    4.517    4.884

                03HR     02HR     01HR     00HR     23HR     22HR     21HR     20HR

                4.425    4.934    4.463    4.463    4.684    4.338    5.017    4.836

                19HR     18HR     17HR     16HR     15HR     14HR     13HR     12HR

                5.042    5.138    5.361    5.286    5.358    5.245    4.845    4.858

DAY AVERAGE     WED 12   TUE 11   MON 10   SUN 09   SAT 08   FRI 07   THR 06

                6.832    5.848    5.265    4.285    4.371    4.043    4.860
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   1150    12-13-88       PAGE PRINT      CONSOLE    4
                                                              11:50:40  12-13-88

RA13235          #3 HH STACK O2 INDICATE    TIME : 11:50

6 MIN. AVERAGE  11HR     10HR     09HR     08HR     07HR     06HR     05HR     04HR

             57          5.579    5.358    20.91    21.08    5.462    5.556    5.354

             51          7.306    5.405    20.91    21.24    5.551    5.619    5.342

             45  5.311   5.578    7.040    20.90    21.21    5.596    5.522    5.565

             39  5.241   5.452    5.612    20.91    15.90    7.049    5.566    5.588

x            33  5.216   5.587    5.776    20.91    5.524    5.514    7.587    5.859

             27  5.310   5.665    13.40    20.91    5.552    5.659    5.458    5.586

             21  5.838   7.660    20.91    20.90    5.709    5.708    5.502    5.656

             15  5.394   5.541    20.91    20.90    5.739    5.876    5.577    5.690

             09  5.521   5.354    20.91    20.90    5.773    8.039    5.570    5.781

             03  5.403   5.319    20.90    20.91    5.614    5.941    6.073    5.586

HOUR AVERAGE     11HR    10HR     09HR     08HR     07HR     06HR     05HR     04HR

                 5.388   5.908    11.58    20.89    12.35    6.018    5.763    5.652

                 03HR    02HR     01HR     00HR     23HR     22HR     21HR     20HR

                 5.759   6.141    5.797    5.690    6.114    7.681    5.601    5.809

                 19HR    18HR     17HR     16HR     15HR     14HR     13HR     12HR

                 6.029   6.126    5.755    5.745    6.129    6.002    5.908    5.870

DAY AVERAGE     WED 12  TUE 11   MON 10   SUN 09   SAT 08   FRI 07   THR 06

                 8.443   7.826    7.275    6.713    7.164    9.093    9.249
```

APPENDIX C

SAMPLE SHIPMENT LETTER

RADIAN

December 15, 1984

U. S. EPA ECC Toxicant Analysis Center
Building 1105
Bay St. Louis, MO 39529

Attention: Danny McDaniel

Subject: Tier 4 - Analysis Instructions

Dear Sir:

The objective of this letter is to clarify instructions and priorities for individual samples from specific Tier 4 combustion sites. This instruction letter is No. 4 and pertains to EPA Site No. Q4 at

The Episode No. is 2549, and SCC numbers assigned to this site were numbers DQ000401 through DQ000499.

SCC numbers DQ000401 through DQ000406 have been assigned to Troika for internal QA/QC purposes. SCC numbers DQ000407 through DQ000418 have been assigned to samples included in this shipment and numbers DQ000419 have been assigned to samples being archived at Radian. All remaining SCC numbers are unused.

The sample shipment for EPA Site No. Q4 consists of 4 boxes containing 57 samples in 67 containers.(Note-The Modified Method 5 samples are comprised of 6 components as listed below.Some MM5 sample runs have more than one container per component as indicated by asterisk.) The sample shipment was shipped air freight on December 15, 1984 by Federal Express under Airbill(s) No.770332533 and No.544549655

Instructions for extraction and analysis follow.

1. The following samples require immediate extraction and analysis (Priority #1 samples).

Radian Run #04-MM5-B-01
(Total of 6 train components)

SCC #	Component	Fraction
DQ000407	1	Filter
DQ000407	2*(3 containers)	Probe Rinse
DQ000407	3	Back Half/Coil Rinse
DQ000407	4* (2 containers)	Condensate
DQ000407	5	Impinger Solution
DQ000407	6	XAD Module

Radian Run # 04-MM5-BLANK
(Total of 6 train components)

SCC #	Components	Fraction
DQ000408	1	Filter
DQ000408	2	Probe Rinse
DQ000408	3	Back Half/Coil Rinse
DQ000408	4	Condensate
DQ000408	5	Impinger Solution
DQ000408	6	XAD Module

Radian Run # 04-MM5-C-01
(Total of 6 train components)

SCC #	Components	Fraction
DQ000409	1	Filter
DQ000409	2	Probe Rinse
DQ000409	3	Back Half/Coil Rinse
DQ000409	4*(2 container)	Condensate
DQ000409	5	Impinger Solution
DQ000409	6	XAD Module

Radian Run #04-MM5-B-02
(Total of 6 train components)

SCC #	Components	Fraction
DQ000411	1	Filter
DQ000411	2*(3 containers)	Probe Rinse
DQ000411	3	Back Half/Coil Rinse
DQ000411	4	Condensate
DQ000411	5	Impinger Solution
DQ000411	6	XAD Module

Radian Run # 04-MM5-C-02
(Total of 6 train components)

SCC #	Components	Fraction
DQ000412	1	Filter
DQ000412	2	Probe Rinse
DQ000412	3	Back Half/Coil Rinse
DQ000412	4*(2 containers)	Condensate
DQ000412	5	Impinger Solution
DQ000412	6*(2 containers)	XAD Module

Radian Run # 04-MM5-B-BLANK
(Total of 6 train components)

SCC #	Components	Fraction
DQ000414	1	Filter
DQ000414	2	Probe Rinse
DQ000414	3	Back Half/Coil Rinse
DQ000414	4	Condensate
DQ000414	5	Impinger Solution
DQ000414	6	XAD Module

Radian Run # 04-MM5-C-BLANK
(Total of 6 train components)

SCC #	Components	Fraction
DQ000415	1	Filter
DQ000415	2	Probe Rinse
DQ000415	3	Back Half/Coil Rinse
DQ000415	4	Condensate
DQ000415	5	Impinger Solution
DQ000415	6	XAD Module

Radian Run # 04-MM5-B-03
(Total of 6 train components)

SCC #	Components	Fraction
DQ000416	1	Filter
DQ000416	2*(2 containers)	Probe Rinse
DQ000416	3	Back Half/Coil Rinse
DQ000416	4	Condensate
DQ000416	5	Impinger Solution
DQ000416	6	XAD Module

Radian Run # 04-MM5-C-03
(Total of 6 train components)

SCC #	Components	Fraction
DQ000417	1	Filter
DQ000417	2*(2 containers)	Probe Rinse
DQ000417	3	Back Half/Coil Rinse
DQ000417	4	Condensate
DQ000417	5	Impinger Solution
DQ000417	6	XAD Module

2. The strong black liquor samples are the only Priority #2 samples. They should be held for analysis by Troika pending the results of Priority #1 sample analysis.

SCC #	Sample	
DQ000410	SBL-01	Strong black liquor
DQ000413	SBL-02	Strong black liquor
DQ000418	SBL-03	Strong black liquor

3. The soil sample is the only Priority #3 sample. It will be held by Radian for analysis by Troika pending the results of Priority #1 and Priority #2 sample analyses.

SCC #	Sample	
DQ000419	# 04-S-01	Soils

If there are any questions concerning this sample shipment, please contact either Bob Jongleux or Larry Keller at Radian Corporation (919) 541-9100.

Sincerely,

Robert F. Jongleux

TEST TEAM LEADER

APPENDIX D

DIOXIN/FURAN ANALYTICAL DATA FOR MM5 SAMPLE TRAINS

TABLE D-1. DIOXIN/FURAN ANALYTICAL DATA FOR MM5 TRAINS AT THE ESP INLET

Isomer/Homologue	Amount Detected Picograms Per Train		
	Run 01	Run 02	Run 03
DIOXINS			
2378 TCDD	ND (80)	ND (50)	ND (180)
Other TCDD	ND (60)	ND (200)	ND (400)
Penta-CDD	ND (310)	ND (60)	ND (240)
Hexa-CDD	500	200	ND (940)
Hepta-CDD	1200	500	1400
Octa-CDD	3300	1600	4900
TOTAL CDD	4000	2300	6300
FURANS			
2378 TCDF	ND (80)	50	ND (180)
Other TCDF	1000	500	1000
Penta-CDF	1300	600	ND (1480)
Hexa-CDF	1800	1000	1900
Hepta-CDF	1000	300	900
Octa-CDF	300	200	ND (630)
TOTAL CDF	5400	2650	3800

TABLE D-2. DIOXIN/FURAN ANALYTICAL DATA FOR MM5 TRAINS AT THE ESP OUTLET

Isomer/Homologue	Amount Detected Picograms Per Train Run 01	Run 02	Run 03
DIOXINS			
2378 TCDD	ND (310)	ND (100)	ND (110)
Other TCDD	ND (310)	300	ND (110)
Penta-CDD	ND (130)	ND (120)	ND (220)
Hexa-CDD	800	ND (320)	ND (240)
Hepta-CDD	1600	500	500
Octa-CDD	3700	2200	1300
TOTAL PCDD	6100	3000	1800
FURANS			
2378 TCDF	ND (40)	ND (200)	ND (100)
Other TCDF	1700	300	200
Penta-CDD	800	ND (230)	ND (130)
Hexa-CDD	700	300	ND (510)
Hepta-CDD	1000	1000	300
Octa-CDD	400	1500	100
TOTAL PCDD	4600	3100	600

APPENDIX E

RUN-SPECIFIC DIOXIN/FURAN EMISSIONS DATA

E-1 Run-specific Dioxin/Furan Emissions Data at the ESP Inlet (As-measured Concentrations)

E-2 Run-specific Dioxin/Furan Emissions Data at the ESP Outlet (As-measured Concentrations)

E-3 Run-specific Dioxin/Furan Emissions Data at the ESP Inlet (Concentrations Corrected to 3 Percent Oxygen)

E-4 Run-specific Dioxin/Furan Emissions Data at the ESP Outlet (Concentrations Corrected to 3 Percent Oxygen)

APPENDIX E-1

RUN-SPECIFIC DIOXIN/FURAN EMISSIONS DATA AT THE ESP INLET

(As-measured Concentrations)

TABLE E-1. DIOXIN/FURAN EMISSIONS DATA AT THE ESP INLET FOR RUN 01, SITE BLB-A (AS-MEASURED CONCENTRATIONS)

Dioxin/Furan Isomer	Isomer Concentration In Flue Gas (ng/dscm)	Isomer Concentration In Flue Gas (ppt)	Isomer Hourly Emissions Rate (ug/hr)
DIOXINS			
2378 TCDD	ND (1.94E-02)	ND (1.45E-03)	ND (4.47E+00)
Other TCDD	ND (1.94E-02)	ND (1.45E-03)	ND (4.47E+00)
Penta-CDD	ND (7.52E-02)	ND (5.08E-03)	ND (1.73E+01)
Hexa-CDD	1.21E-01(N/A)	7.47E-03(N/A)	2.80E+01
Hepta-CDD	2.91E-01(N/A)	1.65E-02(N/A)	6.71E+01
Octa-CDD	8.01E-01(N/A)	4.19E-02(N/A)	1.85E+02
Total PCDD	1.21E+00	6.58E-02	2.80E+02
FURANS			
2378 TCDF	ND (1.46E-02)	ND (1.14E-03)	ND (3.36E+00)
Other TCDF	2.43E-01(N/A)	1.91E-02(N/A)	5.59E+01
Penta-CDF	3.16E-01(N/A)	2.23E-02(N/A)	7.27E+01
Hexa-CDF	4.37E-01(N/A)	2.80E-02(N/A)	1.01E+02
Hepta-CDF	2.43E-01(N/A)	1.43E-02(N/A)	5.59E+01
Octa-CDF	7.28E-02(N/A)	3.95E-03(N/A)	1.68E+01
Total PCDF	1.31E+00	8.77E-02	3.02E+02

NOTE: Isomer concentrations shown are at as-measured oxygen conditions.
ND = not detected (detection limit in parenthesis).
N/A = detection limit not applicable. QA samples indicate the detection limit for positive samples.
ng = 1.0E-09g
ug = 1.0E-06g
ppt = parts per trillion, dry volume basis
8760 operating hours per year

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TABLE E-2. DIOXIN/FURAN EMISSIONS DATA AT THE ESP INLET FOR RUN 02, SITE BLB-A (AS-MEASURED CONCENTRATIONS)

Dioxin/Furan Isomer	Isomer Concentration In Flue Gas (ng/dscm)	Isomer Concentration In Flue Gas (ppt)	Isomer Hourly Emissions Rate (ug/hr)
DIOXINS			
2378 TCDD	ND (1.98E-02)	ND (1.48E-03)	ND (4.38E+00)
Other TCDD	1.98E-02(N/A)	1.48E-03(N/A)	4.38E+00
Penta-CDD	ND (2.38E-02)	ND (1.61E-03)	ND (5.26E+00)
Hexa-CDD	7.94E-02(N/A)	4.88E-03(N/A)	1.75E+01
Hepta-CDD	1.98E-01(N/A)	1.12E-02(N/A)	4.38E+01
Octa-CDD	6.35E-01(N/A)	3.32E-02(N/A)	1.40E+02
Total PCDD	9.33E-01	5.08E-02	2.06E+02
FURANS			
2378 TCDF	ND (7.94E-02)	ND (6.24E-03)	ND (1.75E+01)
Other TCDF	1.98E-01(N/A)	1.56E-02(N/A)	4.38E+01
Penta-CDF	2.38E-01(N/A)	1.68E-02(N/A)	5.26E+01
Hexa-CDF	3.97E-01(N/A)	2.55E-02(N/A)	8.76E+01
Hepta-CDF	1.19E-01(N/A)	7.00E-03(N/A)	2.63E+01
Octa-CDF	7.94E-02(N/A)	4.30E-03(N/A)	1.75E+01
Total PCDF	1.03E+00	6.92E-02	2.28E+02

NOTE: Isomer concentrations shown are at as-measured oxygen conditions.

ND = not detected (detection limit in parenthesis).
N/A = detection limit not applicable. QA samples indicate the detection limit for positive samples.
ng = 1.0E-09g
ug = 1.0E-06g
ppt = parts per trillion, dry volume basis
8760 operating hours per year

TABLE E-3. DIOXIN/FURAN EMISSIONS DATA AT THE ESP INLET FOR RUN 03 — SITE BLB-A (AS-MEASURED CONCENTRATIONS)

Dioxin/Furan Isomer	Isomer Concentration In Flue Gas (ng/dscm)	Isomer Concentration In Flue Gas (ppt)	Isomer Hourly Emissions Rate (ug/hr)
DIOXINS			
2378 TCDD	ND (7.47E-02)	ND (5.58E-03)	ND (1.51E+01)
Other TCDD	ND (7.47E-02)	ND (5.58E-03)	ND (1.51E+01)
Penta-CDD	ND (9.96E-02)	ND (6.73E-03)	ND (2.02E+01)
Hexa-CDD	ND (3.90E-01)	ND (2.40E-02)	ND (7.91E+01)
Hepta-CDD	5.81E-01(N/A)	3.29E-02(N/A)	1.18E+02
Octa-CDD	2.03E+00(N/A)	1.06E-01(N/A)	4.12E+02
Total PCDD	2.61E+00	1.39E-01	5.30E+02
FURANS			
2378 TCDF	ND (1.66E-01)	ND (1.30E-02)	ND (3.36E+01)
Other TCDF	4.15E-01(N/A)	3.26E-02(N/A)	8.41E+01
Penta-CDF	ND (6.14E-01)	ND (4.34E-02)	ND (1.25E+02)
Hexa-CDF	7.88E-01(N/A)	5.06E-02(N/A)	1.60E+02
Hepta-CDF	3.73E-01(N/A)	2.20E-02(N/A)	7.57E+01
Octa-CDF	ND (2.61E-01)	ND (1.42E-02)	ND (5.30E+01)
Total PCDF	1.58E+00	1.05E-01	3.20E+02

NOTE: Isomer concentrations shown are at as-measured oxygen conditions.

ND = not detected (detection limit in parenthesis).
N/A = detection limit not applicable. QA samples indicate the detection limit for positive samples.
ng = 1.0E-09g
ug = 1.0E-06g
ppt = parts per trillion, dry volume basis
8760 operating hours per year

APPENDIX E-2

RUN-SPECIFIC DIOXIN/FURAN EMISSIONS DATA AT THE ESP OUTLET

(As-measured Concentrations)

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TABLE E-4. DIOXIN/FURAN EMISSIONS DATA AT THE ESP OUTLET FOR RUN 01, SITE BLB-A (AS-MEASURED CONCENTRATIONS)

Dioxin/Furan Isomer	Isomer Concentration In Flue Gas (ng/dscm)	Isomer Concentration In Flue Gas (ppt)	Isomer Hourly Emissions Rate (ug/hr)
DIOXINS			
2378 TCDD	ND (6.00E-02)	ND (4.48E-03)	ND (1.36E+01)
Other TCDD	ND (6.00E-02)	ND (4.48E-03)	ND (1.36E+01)
Penta-CDD	ND (2.51E-02)	ND (1.70E-03)	ND (5.71E+00)
Hexa-CDD	1.55E-01(N/A)	9.52E-03(N/A)	3.52E+01
Hepta-CDD	3.09E-01(N/A)	1.75E-02(N/A)	7.03E+01
Octa-CDD	7.16E-01(N/A)	3.74E-02(N/A)	1.63E+02
Total PCDD	1.18E+00	6.45E-02	2.68E+02
FURANS			
2378 TCDF	ND (7.74E-03)	ND (6.08E-04)	ND (1.76E+00)
Other TCDF	3.29E-01(N/A)	2.58E-02(N/A)	7.47E+01
Penta-CDF	1.55E-01(N/A)	1.09E-02(N/A)	3.52E+01
Hexa-CDF	1.35E-01(N/A)	8.69E-03(N/A)	3.08E+01
Hepta-CDF	1.93E-01(N/A)	1.14E-02(N/A)	4.40E+01
Octa-CDF	7.74E-02(N/A)	4.19E-03(N/A)	1.76E+01
Total PCDF	8.90E-01	6.11E-02	2.02E+02

NOTE: Isomer concentrations shown are at as-measured oxygen conditions.

ND = not detected (detection limit in parenthesis).
N/A = detection limit not applicable. QA samples indicate the detection limit for positive samples.
ng = 1.0E-09g
ug = 1.0E-06g
ppt = parts per trillion, dry volume basis
8760 operating hours per year

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TABLE E-5. DIOXIN/FURAN EMISSIONS DATA AT THE ESP OUTLET FOR RUN 02, SITE BLB-A (AS-MEASURED CONCENTRATIONS)

Dioxin/Furan Isomer	Isomer Concentration In Flue Gas (ng/dscm)	Isomer Concentration In Flue Gas (ppt)	Isomer Hourly Emissions Rate (ug/hr)
DIOXINS			
2378 TCDD	ND (1.69E-02)	ND (1.26E-03)	ND (3.78E+00)
Other TCDD	5.06E-02(N/A)	3.78E-03(N/A)	1.13E+01
Penta-CDD	ND (2.02E-02)	ND (1.37E-03)	ND (4.54E+00)
Hexa-CDD	ND (5.40E-02)	ND (3.32E-03)	ND (1.21E+01)
Hepta-CDD	8.43E-02(N/A)	4.77E-03(N/A)	1.89E+01
Octa-CDD	3.71E-01(N/A)	1.94E-02(N/A)	8.32E+01
Total PCDD	5.06E-01	2.80E-02	1.13E+02
FURANS			
2378 TCDF	ND (3.37E-02)	ND (2.65E-03)	ND (7.56E+00)
Other TCDF	5.06E-02(N/A)	3.98E-03(N/A)	1.13E+01
Penta-CDF	ND (3.88E-02)	ND (2.74E-03)	ND (8.70E+00)
Hexa-CDF	5.06E-02(N/A)	3.25E-03(N/A)	1.13E+01
Hepta-CDF	1.69E-01(N/A)	9.92E-03(N/A)	3.78E+01
Octa-CDF	2.53E-01(N/A)	1.37E-02(N/A)	5.67E+01
Total PCDF	5.23E-01	3.08E-02	1.17E+02

NOTE: Isomer concentrations shown are at as-measured oxygen conditions.

ND = not detected (detection limit in parenthesis).
N/A = detection limit not applicable. QA samples indicate the detection limit for positive samples.
ng = 1.0E-09g
ug = 1.0E-06g
ppt = parts per trillion, dry volume basis
8760 operating hours per year

TABLE E-6. DIOXIN/FURAN EMISSIONS DATA AT THE ESP OUTLET FOR RUN 03, SITE BLB-A (AS-MEASURED CONCENTRATIONS)

Dioxin/Furan Isomer	Isomer Concentration In Flue Gas (ng/dscm)	Isomer Concentration In Flue Gas (ppt)	Isomer Hourly Emissions Rate (ug/hr)
DIOXINS			
2378 TCDD	ND (1.88E-02)	ND (1.41E-03)	ND (4.08E+00)
Other TCDD	ND (1.88E-02)	ND (1.41E-03)	ND (4.08E+00)
Penta-CDD	ND (3.77E-02)	ND (2.55E-03)	ND (8.15E+00)
Hexa-CDD	ND (4.11E-02)	ND (2.53E-03)	ND (8.89E+00)
Hepta-CDD	8.56E-02(N/A)	4.85E-03(N/A)	1.85E+01
Octa-CDD	2.23E-01(N/A)	1.16E-02(N/A)	4.82E+01
Total PCDD	3.08E-01	1.65E-02	6.67E+01
FURANS			
2378 TCDF	ND (1.71E-02)	ND (1.35E-03)	ND (3.71E+00)
Other TCDF	3.42E-02(N/A)	2.69E-03(N/A)	7.41E+00
Penta-CDF	ND (2.23E-02)	ND (1.57E-03)	ND (4.82E+00)
Hexa-CDF	ND (8.73E-02)	ND (5.60E-03)	ND (1.89E+01)
Hepta-CDF	5.14E-02(N/A)	3.02E-03(N/A)	1.11E+01
Octa-CDF	1.71E-02(N/A)	9.28E-04(N/A)	3.71E+00
Total PCDF	1.03E-01	6.64E-03	2.22E+01

NOTE: Isomer concentrations shown are at as-measured oxygen conditions.

ND = not detected (detection limit in parenthesis).
N/A = detection limit not applicable. QA samples indicate the detection limit for positive samples.
ng = 1.0E-09g
ug = 1.0E-06g
ppt = parts per trillion, dry volume basis
8760 operating hours per year

APPENDIX E-3

RUN-SPECIFIC DIOXIN/FURAN EMISSIONS DATA AT THE ESP INLET

(Concentrations Corrected to 3 Percent Oxygen)

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TABLE E-7. DIOXIN/FURAN EMISSIONS DATA AT THE ESP INLET FOR RUN 01, SITE BLB-A (CONCENTRATIONS CORRECTED TO 3 PERCENT OXYGEN)

Dioxin/Furan Isomer	Isomer Concentration In Flue Gas (ng/dscm @ 3% oxygen)	Isomer Concentration In Flue Gas (ppt @ 3% oxygen)	Isomer Hourly Emissions Rate (ug/hr)
DIOXINS			
2378 TCDD	ND (2.18E-02)	ND (1.63E-03)	ND (4.47E+00)
Other TCDD	ND (2.18E-02)	ND (1.63E-03)	ND (4.47E+00)
Penta-CDD	ND (8.46E-02)	ND (5.72E-03)	ND (1.73E+01)
Hexa-CDD	1.37E-01(N/A)	8.40E-03(N/A)	2.80E+01
Hepta-CDD	3.28E-01(N/A)	1.85E-02(N/A)	6.71E+01
Octa-CDD	9.01E-01(N/A)	4.71E-02(N/A)	1.85E+02
Total PCDD	1.37E+00	7.41E-02	2.80E+02
FURANS			
2378 TCDF	ND (1.64E-02)	ND (1.29E-03)	ND (3.36E+00)
Other TCDF	2.73E-01(N/A)	2.15E-02(N/A)	5.59E+01
Penta-CDF	3.55E-01(N/A)	2.51E-02(N/A)	7.27E+01
Hexa-CDF	4.92E-01(N/A)	3.15E-02(N/A)	1.01E+02
Hepta-CDF	2.73E-01(N/A)	1.61E-02(N/A)	5.59E+01
Octa-CDF	8.19E-02(N/A)	4.44E-03(N/A)	1.68E+01
Total PCDF	1.47E+00	9.86E-02	3.02E+02

NOTE: Isomer concentrations shown are corrected to 3% oxygen.

ND = not detected (detection limit in parenthesis).
N/A = detection limit not applicable. QA samples indicate the detection limit for positive samples.
ng = 1.0E-09g
ug = 1.0E-06g
ppt = parts per trillion, dry volume basis
8760 operating hours per year

TABLE E-8. DIOXIN/FURAN EMISSIONS DATA AT THE ESP INLET FOR RUN 02, SITE BLB-A (CONCENTRATIONS CORRECTED TO 3 PERCENT OXYGEN)

Dioxin/Furan Isomer	Isomer Concentration In Flue Gas (ng/dscm @ 3% oxygen)	Isomer Concentration In Flue Gas (ppt @ 3% oxygen)	Isomer Hourly Emissions Rate (ug/hr)
DIOXINS			
2378 TCDD	ND (2.23E-02)	ND (1.67E-03)	ND (4.38E+00)
Other TCDD	2.23E-02(N/A)	1.67E-03(N/A)	4.38E+00
Penta-CDD	ND (2.68E-02)	ND (1.81E-03)	ND (5.26E+00)
Hexa-CDD	8.93E-02(N/A)	5.49E-03(N/A)	1.75E+01
Hepta-CDD	2.23E-01(N/A)	1.26E-02(N/A)	4.38E+01
Octa-CDD	7.14E-01(N/A)	3.74E-02(N/A)	1.40E+02
Total PCDD	1.05E+00	5.71E-02	2.06E+02
FURANS			
2378 TCDF	ND (8.93E-02)	ND (7.02E-03)	ND (1.75E+01)
Other TCDF	2.23E-01(N/A)	1.75E-02(N/A)	4.38E+01
Penta-CDF	2.68E-01(N/A)	1.90E-02(N/A)	5.26E+01
Hexa-CDF	4.46E-01(N/A)	2.86E-02(N/A)	8.76E+01
Hepta-CDF	1.34E-01(N/A)	7.88E-03(N/A)	2.63E+01
Octa-CDF	8.93E-02(N/A)	4.84E-03(N/A)	1.75E+01
Total PCDF	1.16E+00	7.79E-02	2.28E+02

NOTE: Isomer concentrations shown are corrected to 3% oxygen.

ND = not detected (detection limit in parenthesis).
N/A = detection limit not applicable. QA samples indicate the detection limit for positive samples.
ng = 1.0E-09g
ug = 1.0E-06g
ppt = parts per trillion, dry volume basis
8760 operating hours per year

TABLE E-9.—DIOXIN/FURAN EMISSIONS DATA AT THE ESP INLET FOR RUN 03, SITE BLB-A (CONCENTRATIONS CORRECTED TO 3 PERCENT OXYGEN)

Dioxin/Furan Isomer	Isomer Concentration In Flue Gas (ng/dscm @ 3% oxygen)	Isomer Concentration In Flue Gas (ppt @ 3% oxygen)	Isomer Hourly Emissions Rate (ug/hr)
DIOXINS			
2378 TCDD	ND (8.40E-02)	ND (6.28E-03)	ND (1.51E+01)
Other TCDD	ND (8.40E-02)	ND (6.28E-03)	ND (1.51E+01)
Penta-CDD	ND (1.12E-01)	ND (7.57E-03)	ND (2.02E+01)
Hexa-CDD	ND (4.39E-01)	ND (2.70E-02)	ND (7.91E+01)
Hepta-CDD	6.54E-01(N/A)	3.70E-02(N/A)	1.18E+02
Octa-CDD	2.29E+00(N/A)	1.20E-01(N/A)	4.12E+02
Total PCDD	2.94E+00	1.57E-01	5.30E+02
FURANS			
2378 TCDF	ND (1.87E-01)	ND (1.47E-02)	ND (3.36E+01)
Other TCDF	4.67E-01(N/A)	3.67E-02(N/A)	8.41E+01
Penta-CDF	ND (6.91E-01)	ND (4.89E-02)	ND (1.25E+02)
Hexa-CDF	8.87E-01(N/A)	5.69E-02(N/A)	1.60E+02
Hepta-CDF	4.20E-01(N/A)	2.47E-02(N/A)	7.57E+01
Octa-CDF	ND (2.94E-01)	ND (1.59E-02)	ND (5.30E+01)
Total PCDF	1.77E+00	1.18E-01	3.20E+02

NOTE: Isomer concentrations shown are corrected to 3% oxygen.

ND = not detected (detection limit in parenthesis).
N/A = detection limit not applicable. QA samples indicate the detection limit for positive samples.
ng = 1.0E-09g
ug = 1.0E-06g
ppt = parts per trillion, dry volume basis
8760 operating hours per year

APPENDIX E-4

RUN-SPECIFIC DIOXIN/FURAN EMISSIONS DATA AT THE ESP OUTLET

(Concentrations Corrected to 3 Percent Oxygen)

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TABLE E-10. DIOXIN/FURAN EMISSIONS DATA AT THE ESP OUTLET FOR RUN 01, SITE BLB-A (CONCENTRATIONS CORRECTED TO 3 PERCENT OXYGEN)

Dioxin/Furan Isomer	Isomer Concentration In Flue Gas (ng/dscm @ 3% oxygen)	Isomer Concentration In Flue Gas (ppt @ 3% oxygen)	Isomer Hourly Emissions Rate (ug/hr)
DIOXINS			
2378 TCDD	ND (6.75E-02)	ND (5.04E-03)	ND (1.36E+01)
Other TCDD	ND (6.75E-02)	ND (5.04E-03)	ND (1.36E+01)
Penta-CDD	ND (2.83E-02)	ND (1.91E-03)	ND (5.71E+00)
Hexa-CDD	1.74E-01(N/A)	1.07E-02(N/A)	3.52E+01
Hepta-CDD	3.48E-01(N/A)	1.97E-02(N/A)	7.03E+01
Octa-CDD	8.05E-01(N/A)	4.21E-02(N/A)	1.63E+02
Total PCDD	1.33E+00	7.25E-02	2.68E+02
FURANS			
2378 TCDF	ND (8.70E-03)	ND (6.84E-04)	ND (1.76E+00)
Other TCDF	3.70E-01(N/A)	2.91E-02(N/A)	7.47E+01
Penta-CDF	1.74E-01(N/A)	1.23E-02(N/A)	3.52E+01
Hexa-CDF	1.52E-01(N/A)	9.77E-03(N/A)	3.08E+01
Hepta-CDF	2.18E-01(N/A)	1.28E-02(N/A)	4.40E+01
Octa-CDF	8.70E-02(N/A)	4.72E-03(N/A)	1.76E+01
Total PCDF	1.00E+00	6.87E-02	2.02E+02

NOTE: Isomer concentrations shown are corrected to 3% oxygen.

ND = not detected (detection limit in parenthesis).
N/A = detection limit not applicable. QA samples indicate the detection limit for positive samples.
ng = 1.0E-09g
ug = 1.0E-06g
ppt = parts per trillion, dry volume basis
8760 operating hours per year

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TABLE E-11. DIOXIN/FURAN EMISSIONS DATA AT THE ESP OUTLET FOR RUN 02, SITE BLB-A (CONCENTRATIONS CORRECTED TO 3 PERCENT OXYGEN)

Dioxin/Furan Isomer	Isomer Concentration In Flue Gas (ng/dscm @ 3% oxygen)	Isomer Concentration In Flue Gas (ppt @ 3% oxygen)	Isomer Hourly Emissions Rate (ug/hr)
DIOXINS			
2378 TCDD	ND (1.97E-02)	ND (1.47E-03)	ND (3.78E+00)
Other TCDD	5.91E-02(N/A)	4.42E-03(N/A)	1.13E+01
Penta-CDD	ND (2.37E-02)	ND (1.60E-03)	ND (4.54E+00)
Hexa-CDD	ND (6.31E-02)	ND (3.88E-03)	ND (1.21E+01)
Hepta-CDD	9.86E-02(N/A)	5.58E-03(N/A)	1.89E+01
Octa-CDD	4.34E-01(N/A)	2.27E-02(N/A)	8.32E+01
Total PCDD	5.91E-01	3.27E-02	1.13E+02
FURANS			
2378 TCDF	ND (3.94E-02)	ND (3.10E-03)	ND (7.56E+00)
Other TCDF	5.91E-02(N/A)	4.65E-03(N/A)	1.13E+01
Penta-CDF	ND (4.53E-02)	ND (3.21E-03)	ND (8.70E+00)
Hexa-CDF	5.91E-02(N/A)	3.79E-03(N/A)	1.13E+01
Hepta-CDF	1.97E-01(N/A)	1.16E-02(N/A)	3.78E+01
Octa-CDF	2.96E-01(N/A)	1.60E-02(N/A)	5.67E+01
Total PCDF	6.11E-01	3.61E-02	1.17E+02

NOTE: Isomer concentrations shown are corrected to 3% oxygen.

ND = not detected (detection limit in parenthesis).
N/A = detection limit not applicable. QA samples indicate the detection limit for positive samples.
ng = 1.0E-09g
ug = 1.0E-06g
ppt = parts per trillion, dry volume basis
8760 operating hours per year

TABLE E-12. DIOXIN/FURAN EMISSIONS DATA AT THE ESP OUTLET FOR RUN 03, SITE BLB-A (CONCENTRATIONS CORRECTED TO 3 PERCENT OXYGEN)

Dioxin/Furan Isomer	Isomer Concentration In Flue Gas (ng/dscm @ 3% oxygen)	Isomer Concentration In Flue Gas (ppt @ 3% oxygen)	Isomer Hourly Emissions Rate (ug/hr)
DIOXINS			
2378 TCDD	ND (2.03E-02)	ND (1.51E-03)	ND (4.08E+00)
Other TCDD	ND (2.03E-02)	ND (1.51E-03)	ND (4.08E+00)
Penta-CDD	ND (4.05E-02)	ND (2.74E-03)	ND (8.15E+00)
Hexa-CDD	ND (4.42E-02)	ND (2.72E-03)	ND (8.89E+00)
Hepta-CDD	9.21E-02(N/A)	5.21E-03(N/A)	1.85E+01
Octa-CDD	2.40E-01(N/A)	1.25E-02(N/A)	4.82E+01
Total PCDD	3.32E-01	1.77E-02	6.67E+01
FURANS			
2378 TCDF	ND (1.84E-02)	ND (1.45E-03)	ND (3.71E+00)
Other TCDF	3.68E-02(N/A)	2.90E-03(N/A)	7.41E+00
Penta-CDF	ND (2.40E-02)	ND (1.69E-03)	ND (4.82E+00)
Hexa-CDF	ND (9.40E-02)	ND (6.03E-03)	ND (1.89E+01)
Hepta-CDF	5.53E-02(N/A)	3.25E-03(N/A)	1.11E+01
Octa-CDF	1.84E-02(N/A)	9.98E-04(N/A)	3.71E+00
Total PCDF	1.11E-01	7.15E-03	2.22E+01

NOTE: Isomer concentrations shown are corrected to 3% oxygen.

ND = not detected (detection limit in parenthesis).
N/A = detection limit not applicable. QA samples indicate the detection limit for positive samples.
ng = 1.0E-09g
ug = 1.0E-06g
ppt = parts per trillion, dry volume basis
8760 operating hours per year

APPENDIX F

RUN-SPECIFIC RISK MODELING INPUT DATA

TABLE F-1. RISK MODELING PARAMETERS FOR RUN 01, SITE BLB-A

Latitude = 34 50 39
Longitude = 80 53 22
Stack Height (From Grade Level) = 68.6 m
Stack Diameter (ID) = 3.2 m
Flue Gas Flow Rate (Dry Standard) = 3787.2 dscmm
Flue Gas Exit Temperature = 448.0 K
Flue Gas Exit Velocity (Actual) = 1003.1 mpm

Dioxin/Furan Isomer	Isomer Concentration In Flue Gas (ng/dscm)	Isomer Hourly Emissions Rate (ug/hr)	Relative Potency Factor	2,3,7,8 - TCDD Equivalent Emissions (mg/yr)
2378 TCDD	ND (6.00E-02)	ND (1.36E+01)	1.000	ND (1.19E+02)
Other TCDD	ND (6.00E-02)	ND (1.36E+01)	.010	ND (1.19E+00)
2378 TCDF	ND (7.74E-03)	ND (1.76E+00)	.100	ND (1.54E+00)
Other TCDF	3.29E-01	7.47E+01	.001	6.55E-01
Penta-CDD	ND (2.51E-02)	ND (5.71E+00)	.500	ND (2.50E+01)
Penta-CDF	1.55E-01	3.52E+01	.100	3.08E+01
Hexa-CDD	1.55E-01	3.52E+01	.040	1.23E+01
Hexa-CDF	1.35E-01	3.08E+01	.010	2.70E+00
Hepta-CDD	3.09E-01	7.03E+01	.001	6.16E-01
Hepta-CDF	1.93E-01	4.40E+01	.001	3.85E-01
Octa-CDD	7.16E-01	1.63E+02	.000	.00E+00
Octa-CDF	7.74E-02	1.76E+01	.000	.00E+00
Net 2378 TCDD Equivalent Atmospheric Loading				4.75E+01

ND = not detected (detection limit in parentheses).
N/A = detection limit not available
ng = 1.0E-09g
ug = 1.0E-06g
mg = 1.0E-03g
Standard conditions: 293 K (20 C) temperature and 1 atmosphere pressure.
8760 operating hours per year

TABLE F-2. RISK MODELING PARAMETERS FOR RUN 02, SITE BLB-A

Latitude = 34 50 39
Longitude = 80 53 22
Stack Height (From Grade Level) = 68.6 m
Stack Diameter (ID) = 3.2 m
Flue Gas Flow Rate (Dry Standard) = 3738.4 dscmm
Flue Gas Exit Temperature = 446.2 K
Flue Gas Exit Velocity (Actual) = 972.5 mpm

Dioxin/Furan Isomer	Isomer Concentration In Flue Gas (ng/dscm)	Isomer Hourly Emissions Rate (ug/hr)	Relative Potency Factor	2,3,7,8 - TCDD Equivalent Emissions (mg/yr)
2378 TCDD	ND (1.69E-02)	ND (3.78E+00)	1.000	ND (3.31E+01)
Other TCDD	5.06E-02	1.13E+01	.010	9.94E-01
2378 TCDF	ND (3.37E-02)	ND (7.56E+00)	.100	ND (6.63E+00)
Other TCDF	5.06E-02	1.13E+01	.001	9.94E-02
Penta-CDD	ND (2.02E-02)	ND (4.54E+00)	.500	ND (1.99E+01)
Penta-CDF	ND (3.88E-02)	ND (8.70E+00)	.100	ND (7.62E+00)
Hexa-CDD	ND (5.40E-02)	ND (1.21E+01)	.040	ND (4.24E+00)
Hexa-CDF	5.06E-02	1.13E+01	.010	9.94E-01
Hepta-CDD	8.43E-02	1.89E+01	.001	1.66E-01
Hepta-CDF	1.69E-01	3.78E+01	.001	3.31E-01
Octa-CDD	3.71E-01	8.32E+01	.000	.00E+00
Octa-CDF	2.53E-01	5.67E+01	.000	.00E+00
Net 2378 TCDD Equivalent Atmospheric Loading				2.58E+00

ND = not detected (detection limit in parentheses).
N/A = detection limit not available
ng = 1.0E-09g
ug = 1.0E-06g
mg = 1.0E-03g
Standard conditions: 293 K (20 C) temperature and 1 atmosphere pressure.
8760 operating hours per year

TABLE F-3. RISK MODELING PARAMETERS FOR RUN 03, SITE BLB-A

Latitude = 34 50 39
Longitude = 80 53 22
Stack Height (From Grade Level) = 68.6 m
Stack Diameter (ID) = 3.2 m
Flue Gas Flow Rate (Dry Standard) = 3607.3 dscmm
Flue Gas Exit Temperature = 445.2 K
Flue Gas Exit Velocity (Actual) = 961.2 mpm

Dioxin/Furan Isomer	Isomer Concentration In Flue Gas (ng/dscm)	Isomer Hourly Emissions Rate (ug/hr)	Relative Potency Factor	2,3,7,8 - TCDD Equivalent Emissions (mg/yr)
2378 TCDD	ND (1.88E-02)	ND (4.08E+00)	1.000	ND (3.57E+01)
Other TCDD	ND (1.88E-02)	ND (4.08E+00)	.010	ND (3.57E-01)
2378 TCDF	ND (1.71E-02)	ND (3.71E+00)	.100	ND (3.25E+00)
Other TCDF	3.42E-02	7.41E+00	.001	6.49E-02
Penta-CDD	ND (3.77E-02)	ND (8.15E+00)	.500	ND (3.57E+01)
Penta-CDF	ND (2.23E-02)	ND (4.82E+00)	.100	ND (4.22E+00)
Hexa-CDD	ND (4.11E-02)	ND (8.89E+00)	.040	ND (3.12E+00)
Hexa-CDF	ND (8.73E-02)	ND (1.89E+01)	.010	ND (1.66E+00)
Hepta-CDD	8.56E-02	1.85E+01	.001	1.62E-01
Hepta-CDF	5.14E-02	1.11E+01	.001	9.74E-02
Octa-CDD	2.23E-01	4.82E+01	.000	.00E+00
Octa-CDF	1.71E-02	3.71E+00	.000	.00E+00
Net 2378 TCDD Equivalent Atmospheric Loading				3.25E-01

ND = not detected (detection limit in parentheses).
N/A = detection limit not available
ng = 1.0E-09g
ug = 1.0E-06g
mg = 1.0E-03g
Standard conditions: 293 K (20 C) temperature and 1 atmosphere pressure.
8760 operating hours per year

APPENDIX G

ERROR ANALYSIS OF CONTROL DEVICE EFFICIENCY CALCULATIONS

APPENDIX G

ERROR ANALYSIS OF CONTROL DEVICE EFFICIENCY CALCULATIONS

Objective: Given the analytical uncertainty of the dioxin/furan analyses (± 50% accuracy), estimate the uncertainty of the control device efficiency calculations.

Let: $C_{out,meas}$ = the measured concentration of a given dioxin/furan homologue at the outlet location.

$C_{in,meas}$ = the measured concentration of a given dioxin/furan homologue at the inlet location.

$C_{out,max}$ = the maximum possible concentration of the dioxin/furan homologue given the measured value $C_{out,meas}$.

$C_{out,min}$ = the minimum possible concentration of the dioxin/furan homologue given the measured value $C_{out,meas}$.

$C_{in,max}$ = the maximum possible concentration of the dioxin/furan homologue, given the measured value $C_{in,meas}$.

$C_{in,min}$ = the minimum possible concentration of the dioxin/furan homologue, given the measured value $C_{in,meas}$.

E = the removal efficiency of the control device

Assuming ± 50 percent analytical accuracy:

$$C_{min} = C_{meas} - 0.5\,C_{meas} = 0.5\,C_{meas}$$

$$C_{max} = C_{meas} + 0.5\,C_{meas} = 1.5\,C_{meas}$$

Note that:
$$E_{max} = \frac{C_{in,max} - C_{out,min}}{C_{in,max}} = 1 - \frac{C_{out,min}}{C_{in,max}}$$

$$E_{max} = 1 - \frac{0.5\,C_{out,meas}}{1.5\,C_{in,meas}} = 1 - {}^{1}/_{3}\,(1 - E_{meas})$$

$$= {}^{2}/_{3} + {}^{1}/_{3}\,E_{meas}$$

and:

$$E_{min} = \frac{C_{in,min} - C_{out,max}}{C_{in,min}} = 1 - \frac{C_{out,max}}{C_{in,min}}$$

$$= 1 - \frac{1.5\ C_{out,meas}}{0.5\ C_{in,meas}}$$

$$= 1 - 3\ (1 - E_{meas})$$

$$E_{min} = 3\ E_{meas} - 2$$

Now, $E_{min} > 0 \Longrightarrow$ positive control (i.e., emissions reduction across the control device)

$$(3E_{meas} - 2) > 0$$

$$E_{meas} > {}^{2}/_{3}$$

Therefore, if E_{meas} is larger than 66.7 percent, the true removal efficiency can safely be assumed to be greater than zero.

And, $E_{max} < 0 \Longrightarrow$ negative control (i.e., emissions increase across the control device)

$${}^{2}/_{3} + {}^{1}/_{3}\ E_{meas} < 0$$

$$E_{meas} < -2$$

Therefore, if E_{meas} is less than -200 percent, the true efficiency can safely be assumed to be less than zero.

To summarize:

$E_{meas} > 66.7$ percent $\Longrightarrow$ positive control

$-200 < E_{meas} < 66.7$ percent $\Longrightarrow$ no definitive conclusions can be drawn

$E_{meas} < -200$ percent $\Longrightarrow$ negative control